THE

YEAR-BOOK OF SCIENCE

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EDITED FOR 1892

BY

PROF. T. G. BONNEY, D.Sc., LL.D., F.R.S.

CASSELL & COMPANY, LIMITED:

LONDON, PARIS & MELBOURNE

1893

LIST OF CONTRIBUTORS.

Charles F. Baker, B.S.
F. A. Bather, M.A., F.G.S.
G. Herbert Fowler, B.A., Ph.D.
P. L. Gray, B.Sc.
J. W. Gregory, F.G.S.
T. T. Groom, B.Sc., F.G.S.
Charles Harding, F.R.Met.Soc.
W. Botting Hemsley, F.R.S., A.L.S.
Thomas Hick, B.A., B.Sc.
H. H. Hoffert, D.Sc.
R. Lydekker
G. Massee
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Harold Picton, B.Sc.
R. I. Pocock
G. T. Prior, M.A.
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H. G. Seeley, F.R.S., F.G.S.
C. S. Sherrington, M.A., M.D.
F. E. Weiss, B.Sc., F.L.S.
Horace B. Woodward, F.G.S.

PREFACE.

As the aim of the YEAR-BOOK OF SCIENCE was fully stated in the preface to the former volume, this need not be repeated on the present occasion. The second volume, on the whole, follows the same general plan as that for 1891, and observes the same limitations of the subjects, but the area covered by some of these has been extended so far as could be done without a considerable increase in the number of pages. For instance, the present issue contains some notes on matters of geographical and anthropological interest, and attempts a more complete treatment of the subject of Zoology. It is hoped that, if the support accorded to the YEAR-BOOK OF SCIENCE justify the Publishers in a further enlargement, these subjects may be more fully treated, and other extensions made possible, in the volume for 1893.

The earlier date of publication will add, it is trusted, to the usefulness of the work. The issue last year was retarded by accidental circumstances to which the Editor then referred. These have not been absent on the present occasion so completely as he had ventured to hope. But the delay thus caused has been slight, owing to the kindness of friends who have given help in time of need, and among whom he has to thank especially Messrs. F. A. Bather, T. T. Groom, R. I. Pocock, and R. Lydekker.

It is hoped that the references in this volume will be

found to be sufficiently precise. In a few cases, however, the page is omitted. This occurs when the notice had been written from a separate copy, independently paged, and a reference to the original source would have materially delayed the proofs. It is, however, believed that these omissions are few—probably not more than a dozen.

T. G. BONNEY.

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The British Association meeting at Edinburgh.

In giving an account of the chief contributions which have been made to physical science during the year 1892, it seems fitting that reference should be made in the first place to the general proceedings of the physical science section of the *British Association*, at its meeting in Edinburgh. Summaries of some of the more important papers read in this section are given in their appropriate places.

A. Schuster, in his presidential address to Section A, discussed the question how to render the advance of scientific knowledge more swift and sure, and illustrated his subject by references to some interesting points relating to modern electrical theories and to cosmical physics.

One of the most important parts of the work done at the British Association meeting was the holding of a conference for the final settlement of the dimensions of the electrical standards. The result of this conference was the adoption of a set of resolutions, which it is to be hoped may become universally accepted, and which may thus settle, once and for all, the international values of the standards. Prof. Helmholtz and M. Guilleaume were present, and took an active part in the framing of the resolutions; there seems some hope, therefore, that this may be the case as far as the Continent is concerned, and it is probable that America will accept the resolutions also. An account of the resolutions will be found in the section of Electricity (p. 62).

A discussion was also held on the proposals of the past-

president, **O. J. Lodge**, for the establishment of a National Physical Laboratory, but it did not lead to any very tangible results.

The evening discourse at the British Association meeting was delivered by **C. V. Boys**, on the subject of the instantaneous photography of projectiles in flight. Apart from the practical importance of Prof. Boys' experiments to the science of gunnery, they have also a high interest from the point of view of pure science. Thus, in order to be enabled to take photographs of a magazine-rifle bullet at its highest speed with the necessary sharpness, Prof. Boys was led to investigate the variations in the luminosity and instantaneity of electric spark discharges under varying conditions, and has arrived at most interesting results. The electric spark from a Leyden jar in an ordinary circuit has a duration which is far too long for the purpose, on account of the too great self induction of the circuit; but by employing a flat condensing pane, the coatings of which are joined by short broad strips of copper, there is sufficient capacity to give a bright spark, which is at the same time of very short duration. The attempts to use, at the spark-gap, terminals of a volatile metal such as aluminium or magnesium, for the purpose of increasing the brilliancy of the spark, were rendered futile by the fact that the duration of the spark was thereby also prolonged. The best results were obtained with copper terminals. The greater portion of the light of the spark comes from its two ends. A long spark is therefore not advantageous, as it does not increase the intensity, while it gives two separate sources of light. Prof. Boys has found that when a short spark gap is employed, the intensity is greatly increased by including in the jar circuit another smaller spark-gap. This is probably because the jar can be raised to a higher potential, so that a larger quantity of electricity passes over in the discharge. By means such as these a spark of sufficient brightness can be produced, the duration of which is only a twenty-five-millionth of a second or less. To photograph the flying bullet, it is made to pass in front of the photographic plate at a distance of a few inches. At the moment of passing the plate the bullet completes an auxiliary electric circuit by joining two lead wires electrically together. By this means it precipitates the spark which makes the photograph by causing a small spark to occur in the second gap in the jar circuit. The main spark is at a distance of a few feet from the plate, on to which it casts a shadow of the projectile. As there are no glass lenses or other absorbing media interposed between the spark and the plate, the full actinic power of the spark is exerted on the plate, and a well-exposed photograph is obtained,

which, unlike those obtained by Mach and Salcher, has the advantage of being of full size or a little larger. In the photographs shown by Prof. Boys, the shadow of a magazine-rifle bullet is perfectly sharply defined, although the projectile was travelling with a speed of 2,000 feet a second or more. Behind the projectile its track is shown on the plate by an appearance recalling the eddies left in the wake of a boat moving through still water; but a still more interesting feature is shown in the shadows of the air-waves occasioned by the motion of the projectile. These appear as straight lines, with dark anterior and light posterior border, which leave the front and back of the projectile at an angle to its path the sine of which is equal to the ratio of the velocity of sound to that of the projectile. The two back lines recall the waves produced in still water by the passage of a boat the stern of which terminates abruptly. The front lines form part of a hyperbolic curve which passes round in front of the projectile at a small distance ahead of it. Where these lines in the photographs obliquely meet the shadows of thin copper plates placed close by, they are seen to be reflected, and in the act of reflection the light posterior and dark anterior borders become reversed. When, however, the waves are incident nearly perpendicularly they do not undergo reflection. At the edge of a reflecting surface of limited extent a curious effect is seen. The wave cut by the edge divides into two parts, one of which continues to pass on beyond the obstacle whilst the other is reflected, and between the two free ends of the waves are seen to curve backward towards the edge of the reflecting surface. The systematic study of waves produced in this way, and their behaviour to various forms of reflecting surfaces, may apparently lead to very important results in connection with the similar behaviour of waves of light, and may, therefore, prove a valuable aid in the study of diffraction. Prof. Boys also showed photographs illustrating the various stages in the passage of a rifle bullet through a sheet of glass. In addition to the waves above described, there are shown in these photographs a series of waves very slightly inclined to the glass plate and symmetrical to it. These waves are caused by the shiver of the plate due to the impact, and the sine of their inclination to the plate gives the ratio of the velocity of propagation of transverse waves in the glass plate to the velocity of sound. They are seen on close examination to be alternately light and dark on the border turned towards the plate, corresponding to the motion of the plate forwards and backwards in its vibration. Those behind the plate are exactly the inverse of those in front.

Air resistance to the motion of falling bodies.

L. Cailletet and **E. Colardeau** have carried out a series of experiments at the Eiffel Tower on the resistance of the air to the motion of bodies through it. In order to determine the position in space at any moment of a body falling freely in air, they attach the body to the extremity of a very fine and light thread, which follows it in its movements without opposing more than a very feeble resistance to its motion. The thread is divided into sections 20 metres long, each of which is wrapped round a cone of wood, fixed vertically with the apex downward. On account of their conical form these cones, although immovable, allow the thread to unwind without any sensible amount of friction. When each section is unwound, the thread breaks an electric contact, and thus moves the style of a chronograph in which an electrically maintained tuning fork records the time with an approximation of about a hundredth of a second. The instants at which the body has traversed 20, 40, 60, etc., metres of its fall are thus recorded. The resistance offered by the thread to the motion was ascertained by allowing the body to fall quite freely, and by comparing the whole time of its fall through a given distance with the time when the thread was attached. It was thus found that the retardation was less than 1 per cent. With this apparatus, Cailletet and Colardeau have confirmed the conclusion that the resistance opposed by the air to planes of equal surface in the direction normal to the surface is independent of the form of the plane, whether circular, square, or triangular; they have, however, reserved for further trial the comparison of rectangles, the two dimensions of which differ considerably from one another. They also find that the resistances to squares of different size are proportional to their surfaces.

The determination of the relationship between the velocity and the air resistance to a surface in motion was made by utilising the fact that after a certain moment the velocity becomes uniform. When this is the case the air resistance for the corresponding velocity is given at once by the weight of the falling body. By varying the load for a given surface the uniform velocity takes different values, and it is thus possible to determine the law of variation of resistance with speed. This law is usually expressed by $P=KV^2$ on the assumption that the air pressure P is equal to the square of the velocity V multiplied by a constant K. Cailletet and Colardeau's determinations show, however, that K is not a constant, but increases with the velocity. For a plane moving at 25 metres per second its value in kilogrammes per sq. metre is 0 071. Langley (see "Year-Book" for 1891, p. 1) had obtained for

velocities of 4·48 to 11·2 metres per second values of K comprised between 0·070 and 0·090, and the variations of K were not always in the same direction as those of V. His mean value 0·80 is higher, notwithstanding the lower velocities, than the value of Cailletet and Colardeau. This difference is easily explicable by the tangential movement of the air in his case. The normal resistance to a surface in motion in the air is always greater when the air possesses a sliding movement along the surface than when it is at rest. (*Comptes Rendus*, cxv. 13.)

Cloudy condensation of steam, and green sun.

The marked increase in the density of the condensation of an ordinary jet of steam when electrified was first shown by Helmholtz, and has since been investigated by Shelford Bidwell, who drew attention to the change of colour of the jet when, its shadow being cast on a white screen, it is electrified by holding near it a point connected to one of the conductors of an electrical machine. The effect is attributed by Bidwell to an increase in the size of the drops produced by electrifying them. **J. Aitken**, who has made an extended investigation of the phenomena connected with cloudy condensation, arrives at the opposite view that the dense form of the jet is not due to an increase in the size of the drops but to an increase in their number, accompanied of course by a diminution in the size. The action of the electricity on the jet is not positive; it seems rather to prevent the collisions of the particles and their consequent coalescence. The density increases gradually with increasing potential of the discharging point used to electrify the jet. Mr. Aitken has found that electrification is only one of the several ways in which the ordinary condensation may be changed into the dense form. Thus the change may be produced by (1) electrification of the jet, (2) an increase in the number of dust nuclei, (3) cold, or low temperature of the air, (4) high pressure of the steam, and (5) obstructions in front of the jet and rough or irregular nozzles.

The most interesting part of Mr. Aitken's investigations is that of the colour phenomena of steam jets. These are best seen when the jet is enclosed in a tube so as to check its admixture with the surrounding air. Thus, for a jet from a nozzle of 1 mm. bore, a tube of 7 or 8 cm. diameter is suitable, and with low pressures of steam, the tube must be partly closed by placing a piece of glass near it so as to reduce the opening. The nozzle is placed outside the tube and a little to one side, so that the eye has a clear view along the axis of the tube. When the amount of steam, dust, and other conditions, are properly proportioned, very beautiful colours are seen, which, with ordinary condensation,

vary from a fine green through pale blue to dark blues of peculiar softness and fulness of colour. On causing the condensation to change to the dense form the colours also change, green to dark blue, blue to dark yellowish brown. It is indifferent in which of the ways the dense condensation is produced. The most usual effect of the change is from blue to yellow. The yellows are not unlike the colours seen through smoke or in a thunder-cloud. Aitken considers it very doubtful whether, as has been supposed, the electricity in a thunder-cloud has anything to do with its lurid colour. The colours can also be produced by sudden exhaustion of moist dusty air in a tube. When produced in this way they are more uniform and equal in all parts than those usually seen in the steam jet. The yellows are also much finer, and the tints more varied. The proof that when the jet is electrified the drops are smaller than when not electrified, is afforded by the behaviour of the yellow condensation, which, as the drops increase in size, changes to blue and finally fades. The change of colour produced by electrification is in the opposite direction, the electrified jet being yellowish brown. The best colours are obtained by expansion of air, derived from a room where gas is burning which is much mixed with products of combustion. The first distinct colour to appear is usually blue, but pale yellow and reddish colours sometimes appear before the blue, into which they imperceptibly change, while the blue itself gives way by degrees to green, yellow, a brownish colour, a mixed purple, blue again, then green and yellow in succession. It is not, however, easy to get the sequence of colours carried so far. The final colour depends on the number of particles present.

Aitken considers that the most probable explanation of these colour phenomena is that they are produced in the same way as the colours in plates. Their order of succession is the same as in the second and third orders of colours of thin plates. With respect to their connection with the phenomena of a blue or green sun, and the eruption of Krakatoa, Aitken observes that such an eruption would throw into the atmosphere a supply of the very materials necessary for producing a green sun by means of drops of water, as it would send into the atmosphere an immense quantity of aqueous vapour, and an enormous amount of fine dust—a combination the most favourable for producing a great number of minute drops of water. Observations on the green sun, in fact, showed that one of the materials necessary for producing this peculiar absorption by means of water drops was present in an unusual amount in the atmosphere at the time.

Aitken finally shows that these colour phenomena afforded an

easy and simple way of estimating, roughly, the number of dust particles in the atmosphere of a room. He has accordingly constructed an apparatus, which he terms a Koniscope, which consists of an air pump and a metal tube with glass ends provided near one end with a communication to the air pump, and near the other with a stopcock for admitting the air to be tested. The inside of the tube is lined with a non-conducting material which is kept wet. The estimation of the number of dust particles is made by noting the depth of the blue colour produced by expansion. The range is wide, from pure white to nearly black-blue, so that estimates of the purity of air are very easily taken with it. (*Proc. Roy. Soc.*, li. 408.)

The appreciation of ultra-visible magnitudes.

G. Johnstone Stoney suggests the adoption of a uniform gauge for the appreciation of ultra-visible quantities. The gauge which he imagines is formed by taking a base line equal in length to the quadrant of the earth's meridian, setting a metre upright at one end of the base, and from the top of it drawing an inclined line to the other end. It is a wedge with a slope of one in ten millions. Small quantities are to be measured by the little perpendicular distances from its base line up to its sloping top. As in molecular physics magnitudes are dealt with that are fractions of a micron, the 10 metres of the gauge nearest its apex suffice for these magnitudes. The smallest separation at which two points must stand (the *minimum visibile*), to admit of their being seen as two, is an ordinate between two and three metres from the apex. All smaller magnitudes are ultra-visible. Of these magnitudes the mean free path of the molecules of a "perfect" gas, at ordinary temperature and pressure, is equal to the ordinate of the gauge at about three-quarters of a metre from the apex. The average interval between the molecules at ordinary pressures and temperatures is represented by the ordinate at 1 cm. from the apex, the size of the molecules themselves by the ordinate at about 1 mm. from the apex. This is the smallest magnitude for which the gauge is convenient.

The dimensions of physical quantities.

W. Williams, in a paper read before the Physical Society of London, has made an important advance in the theory of the dimensions of physical quantities, by introducing the directional relations of the derived to the fundamental units into the dimensions expressed, as usual, in terms of mass, time, and length.

Mr. Williams regards the dimensional formula of the quantity as the symbolical expression of the physical identity of the quantity, so far as it can be defined in terms of those specifications which are arbitrarily taken as fundamental. In carrying out the idea of the relations of the dimensions to directions in space, three rectangular axes are chosen, and unit vector lengths along them are designated respectively by X, Y, Z.

Thus the formulæ specify the dependence of the units, as far as their directional character is concerned, on the rudimentary vector length, and by means of them the physical nature of all concrete quantities becomes symbolically represented, the only quantities having unity as their dimensional formula being pure numbers, and quantities of like nature, viz., ratios between concretes of the same kind.

In the case of quantities involving π, it is shown that, while π is itself a number, it may or may not imply a concrete factor in the relations in which it occurs.

In applying these principles to electromagnetic quantities, Mr. Williams, in accordance with Prof. Rucker's suggestion, introduces the magnetic permeability μ and specific inductive capacity κ of the medium as secondary fundamental units of unknown dimensions, and proceeds to inquire what dimensional values can be assigned to them to render the resulting systems strictly dynamical and capable of mechanical interpretation in our present state of knowledge. For this the following conditions are demanded: (1) the indices of the fundamental units in the dimensional formula must not be fractional; (2) the index of M must not be higher than 1; (3) the indices of X, Y, Z, must not be higher than 2; (4) the index of T must not be higher than 3. Subject to these conditions, and to the relation $[\mu\kappa] = Z^{-2}T^{2}$, it is shown that the probable values of the dimensions of μ reduce to two $M(XYZ)^{-1}$ and $M^{-1}XYZ^{-1}T^{2}$, and the systems of dimensions arising from these (and the corresponding values for κ) lead directly to the two well known rotational theories of electro-magnetism first enunciated by Maxwell and Thomson, and developed by Lodge, Fitzgerald, Heaviside, and others. (*Phil. Mag.* [5], xxxiv. 234.)

W. Ostwald proposes that as "energy" is the only magnitude common to all branches of physics—"mass" being confined, strictly speaking, to dynamics—the fundamental units should be those of space, time, and energy. The substantial existence of matter is rejected, mass being considered as the capacity of an object for energy of motion. (*Zeit. Phys. Chem.*, ix. 563.)

Hardness, plasticity, brittleness, etc.

In the "Year-Book" for 1891, p. 5, an account was given of the investigations of **F. Auerbach** on the measurement of hardness of brittle solids, such as glass and rock-crystal. The definition of hardness adopted by Auerbach for such bodies was based on the maximum pressure at which permanent deformation set in when a spherical and a plane surface of the body were pressed together. In extending the same method of experiment to determine the hardness of more or less plastic bodies, like rock-salt or fluorspar, the difficulty occurs that the limit at which permanent deformation begins lies below the smallest pressures of experiment, and the detection of the deformation depends in a high degree on the delicacy of observation. Thus a critical point, corresponding to the commencement of permanent deformation in brittle solids, does not exist. Auerbach advances reasons therefore for making the definition of hardness depend on the solidity limit rather than on that at which a permanent deformation sets in. In absolutely elastic bodies these limits coincide; but most brittle bodies have a true plasticity, and the first permanent deformation arises sooner than the formation of the crack or separation of parts. But even in brittle bodies the point at which the crack starts is much more sharply observable than the starting of the permanent deformation. By defining hardness, therefore, as that pressing-in-stress at which, in elastic bodies, a separation of the parts occurs, and in plastic bodies a steady strain sets in, a general definition is framed which includes both perfectly elastic and plastic solids.

As in the case of glass and quartz, the hardness of fluorspar, when estimated in this way, depends on the radius ρ of the spherical surface, and the factor $\sqrt[3]{\rho}$ has to be introduced to render the measurements independent of variations of ρ. The hardness thus arrived at is numerically 106. Rock-salt, when measured on one of its cube faces, has a hardness of only 20, or $\frac{1}{5}$ of that of fluorspar, or $\frac{1}{15}$ of that of rock crystal. According to Mohs' scale the ratios should be $2\frac{1}{2} : 4 : 7$. Calcspar presents intermediate features between brittle and plastic solids. The mean of a large series of experiments gave its hardness as 96, which makes it only slightly less hard than fluorspar. (*Wied. Ann.*, xlv. 262.)

In attempting to frame definitions for *brittleness* and *plasticity* Auerbach points out that these two properties are probably to be regarded as different degrees of a single property—plasticity. If a body is subjected to increasing stress of any kind a permanent deformation arises at a given value of the stress. This stress referred to unit area measures the elastic perfection v of the body.

With further increase of the stress to F the body in one place loses the cohesion of its parts and the solidity limit is reached. The plasticity of a body may thus be most simply defined by the difference F—V. For an absolutely brittle body this quantity has the value zero: but the conditions under which it reaches its maximum are not so simple. V may be very small, or F very large, or both these conditions may occur together. Thus plasticity so defined is not an independent property of a solid, but is only a consequence of the relations of two other different properties. As F—V is the difference of two moduli Auerbach terms it the *plasticity modulus*. The ratio of this quantity to the hardness, or solidity modulus, he terms the *plasticity number*, N = (F—V)/F, which is defined as the "excess of the hardness over the elastic perfection expressed as a fraction of the hardness." A third definition arises from the conception that the plasticity is to be estimated not by the range of the stress between the limits of plastic behaviour, but by the magnitude of the plastic strain within this range. Thus the *practical plasticity* or *plasticity ratio* is defined as the magnitude of the change which a body experiences between the limits of elasticity and solidity. This magnitude is connected in a simple manner with the previous one, since to pass from the stress to the strain it is only necessary to multiply by the ratio strain/stress. One and the same body has naturally different plasticity moduli, corresponding to the different varieties of stress.

On comparing the bodies examined with respect to the two properties hardness and plasticity, it is seen that glass and quartz, the two hardest, are also the two most brittle. Rock-salt is the softest and also the most plastic. Nevertheless bodies do not divide themselves into two groups the brittle hard and the plastic soft - for of the two bodies calcspar and fluorspar, the former while softer is the more brittle, while the latter which is the harder is the more plastic. (*Wied. Ann.*, xlv. 277.)

Occlusion of gases.

Bellati and **Lussarra** have made some interesting experiments on the occlusion of hydrogen by nickel. By passing an electric current for a prolonged period through a voltameter of which the negative electrode was a nickel wire, the nickel will absorb as much as 100 times its volume of hydrogen. The occlusion is accompanied by an expansion of the wire, which in the course of 11 days increased in length by about 0·0036 per cent. At the same time the electrical conductivity decreased. The occluded hydrogen is not given off freely; on the contrary, the wires become oxidised on exposure to the air. (*Il Nuovo Cimento*, xxv. 222.)

G. Neumann and **F. Streintz** have made experiments on the occlusion of gases by lead, platinum, palladium, gold, silver, copper, nickel, iron, cobalt, and aluminium, by passing a current of the gas through the molten metal. The lead was melted in a U-tube, and a stream of pure hydrogen passed through it for 6 or 8 hours. The hydrogen was then swept out of the tube by a stream of pure nitrogen, which was not allowed to pass through the lead but only over its surface, as it was found that when the nitrogen was passed through the lead the occluded hydrogen was carried off by it. The U-tube was then connected to a combustion tube containing glowing copper oxide, and to calcium chloride drying-tubes. The lead was strongly heated, a current of pure oxygen sent through the apparatus, and the gain in weight of the calcium chloride tubes was ascertained. The result was to show that lead occluded from 0·11 to 0·15 times its volume of hydrogen. The results obtained for the other metals were—Palladium, 502·35; platinum sponge, 29·95 to 6·48; platinum black, 49·3; gold, 46·32 and 37·31; copper, 4·8; aluminium, 2·72; iron, 19·19 to 9·38; nickel, 17·57 to 16·85; cobalt, 153 to 59·31; all expressed in volumes of the gas absorbed. Silver alone did not absorb any hydrogen. With few exceptions the occluding power of the metals was found to decrease on repetition of the experiment with the same specimen, especially in the case of the noble metals. (*Wied. Ann.*, xlvi. 431.)

Compressibility of liquids.

By a series of experiments on the compressibility of saline solutions, **H. Gilbault** finds, amongst other results, that the compressibilities of solutions of a given salt vary in a continuous manner with the concentration. In dilute solutions the difference between the compressibility of water and that of the solution, called the "saline compressibility," is proportional to the concentration. Beyond a certain concentration, however, the saline compressibility increases less rapidly than the concentration, and if the results for different salts are plotted in curves the abscissæ of which are percentages of salt and the ordinates the compressibilities, all the curves after a suitable orientation are superposable. The compressibilities of very dilute solutions diminish with increase of temperature; those of saturated solutions diminish less slowly, or else increase. Generally there is a concentration at which the compressibility is unaffected by the temperature. (*Comptes Rendus*, cxiv. 209.)

E. H. Amagat gives in the *Comptes Rendus* (cxv. 638) the results of his examination of the compressibilities of a number of liquids. He finds that in all cases the compressibility diminishes as the

pressure increases. In the case of water it is reduced at 3000 atmospheres pressure to about a half of its value at normal pressure, ether to about a third. The diminution is both absolutely and relatively greater as the temperature is higher. Except in the case of water the coefficient of compressibility increases in all cases with the temperature under all pressures.

Viscosity.

R. Cohen has made an investigation, by the method of the flow of liquids through capillary tubes, of the influence of pressure on the viscosity of liquids. He confirms the result, already arrived at by Rontgen, Warburg, and Sachs, that at temperatures below 40° the viscosity of water is diminished by pressure. No minimum of the viscosity can be observed up to pressures of 900 atmospheres and temperatures of 25°; the change of viscosity is, however, not proportional to the pressure, but increases more slowly. It has not been decided whether the viscosity of water increases with pressure at temperatures above 40°. The viscosity of water changes greatly with the temperature, and in the interval 0° to 23° is greatest near 0°. With concentrated solutions of NaCl and NH_4Cl the viscosity increases with the pressure, and the percentage change is almost proportional to the pressure. The influence of temperature is small. The more dilute a solution of NaCl is, the more does the influence of the anomalous behaviour of water preponderate, both as regards the influence of pressure and of temperature. From a 5 per cent. to a 10 per cent. solution there is for each concentration a definite temperature between 2° and 22·5°, at which the influence of a pressure of 600 atmospheres on the viscosity is zero. The change of viscosity of oil of turpentine with pressure is twenty times as great as with a saturated solution of NaCl, and is nearly proportional to the pressure. The direction of the change is the same. The influence of temperature is small, and is in the opposite direction to that of a solution of NaCl. (*Wied. Ann.*, xlv. 666.)

C. Brodman, with a view to elucidate the contradictions met with in the application of calculation to the experimental results in the determination of viscosity by the method of Poiseuille with tubes and that of Coulomb and Meyer with discs, and to determine the connection between viscosity and velocity, has made a series of determinations of viscosity by the method of concentric spheres and cylinders, the outer sphere or cylinder being rotated and the torsion measured which is exerted by the fluid on the inner sphere or cylinder. The observations with concentric spheres confirmed Élié's result that experiments calculated by Kirchhoff's formulæ give values of the viscosity which increase

with increasing velocity of rotation. The cylinder method, however, which in contrast to the preceding allows of more rigorous theoretical treatment, furnishes constant values of the viscosity. This appears to confirm Margules' view that the neglecting of terms of the 2nd order in the differential equations of the motion, leads, even in the case of small velocities, to results which are in contradiction to observation. The values of the viscosity determined by the cylinder method give results closer to Poiseuille's than most of those found by other methods. The cylinder method is also serviceable for very viscous liquids, for which it gives constant values of the viscosity agreeing with theory. The observations confirm Helmholtz's conclusion that water in gilded vessels does not cling but slips. (*Wied. Ann.*, xlv. 159.)

Surface tension of liquids.

W. C. Röntgen describes the following method of obtaining pure liquid surfaces, such as Lord Rayleigh used in his experiments on the optical behaviour of water surfaces freed from contamination. To obtain a pure water surface, the neck of a funnel, 20 cm. wide, is connected by a rubber tube to the town water supply, and the edge of the funnel, which is ground flat, is made as horizontal as possible. The water rising in the funnel and overflowing its edge is received by a second larger funnel enclosing the first, and is then led away by an indiarubber tube. When the water flows slowly a tranquil surface, free from film of contamination, is obtained, which exhibits well the optical properties described by Lord Rayleigh. A similar procedure is found to succeed with mercury. On the longer limb of a U shaped glass tube an inverted glass flask, with the bottom removed, is fastened with a cork. This serves for the reception of the mercury. Over the shorter limb, which is drawn out to a fine point, a small funnel is fixed with sealing-wax, so that the ground edge of the funnel is exactly horizontal. Under the flask is a glass tap without grease. When this is opened the mercury flows into the funnel and overflows its edge into a tray. It is not necessary that the mercury should be specially purified, or that the glass parts should be scrupulously cleansed, unless previously soiled with much grease. The mercury itself performs the final cleansing. As by this process a large quantity of mercury is required, and as owing to the sensitiveness of the surface to contamination it is necessary to renew it repeatedly within a short time, a slight modification of the method may be used with advantage. After setting up the apparatus a quantity of mercury is allowed to flow through it. Before each experiment only

sufficient mercury is allowed to flow into the funnel to make the free surface rise above the edge of the funnel. The overlying portion of the mercury is then as quickly as possible swept off by means of a small, clean strip of glass laid on the edge of the funnel. This operation is if necessary repeated. The cleansing of the glass strip is effected by heating it to redness, although this precaution is not necessary each time. The mercury surface left after stripping off the top layer is extremely mobile, and the degree of purity may with practice be easily seen by the behaviour of small ripples on it. A drop of *clean* water laid on it spreads out into a film extending to the capillary edge of the mercury. If the mercury is not perfectly clean the water forms a flat disc, the diameter of which decreases with decreasing purity of the mercury surface, and at a certain degree of contamination does not spread at all, but remains as a lenticular patch. This shows that the change of surface tension of mercury, as of water, is gradual, and depends on the thickness of the surface film.

The mercury surface is rapidly contaminated by contact with the air. In the open air a drop of water would not spread on it after half a minute, and in a room after three to five minutes. Experiments on various methods of contamination, such as tobacco smoke, various gases and vapours, or air which had been carried over fat, hydrochloric acid, nitric acid, etc., showed that contamination was readily produced by whatever formed a non-volatile layer on it. A layer of a volatile substance produced only a temporary contamination. In some cases the contamination was due to a chemical change of the surface. (*Wied. Ann.*, xlvi. 152.)

Lord Rayleigh describes a simple method of obtaining a mercury surface on which water will spread. The mercury is drawn from below the surface by means of an arrangement resembling an ordinary wash bottle containing some tolerably clean mercury. It is received in watch glasses which have been dipped into strong sulphuric acid, rinsed in distilled water, and dried over a Bunsen flame. The first portion that flows out is rejected. There is thus no difficulty in obtaining a surface on which water will spread, though some failures occur. The spreading of the water proceeds leisurely. Magnesium powder dusted on the surface is not violently repelled as by oil. The difference is probably due to the presence of an aqueous film condensed from the atmosphere.

Lord Rayleigh also describes an interesting series of experiments on surface tension, which he has given in his lectures at the Royal Institution. The behaviour of carbon bisulphide on water appears at first to be an exception to Marangoni's rule, according

to which a liquid of lower surface tension should spread on one of higher surface tension. When a drop of the bisulphide is placed on a clean water surface it remains lenticular. If, however, some lycopodium powder is scattered on the surface, a circular patch round the drop remains bare of dust, and the behaviour of the bisulphide is seen to be due to the fact that though the film is spreading outwards from the drop with a great speed, it is unable to reach any considerable distance on account of its rapid evaporation.

With a strong infusion of horse-chestnuts, bubbles 4 inches in diameter can be blown, which exhibit the characteristic wrinkling of saponine. When the interiors of bubbles of the saponine and of soap solution are put in communication, the saponine contracts and the soap expands. To obtain equilibrium the saponine bubble must be half as large again as the soap-bubble. The foam of Highland waterfalls is due to dissolved vegetable matter. By collecting the foam and allowing it to subside, bubbles up to 4 inches can be blown with the liquid. These bubbles, however, behave like soap solution, and not like saponine.

Lord Rayleigh also alludes to the separation of motes when two immiscible liquids are shaken up together. When water, alcohol and ether, or water and ether, are shaken up together, and after settling the liquid is examined in a strong light, the lower or aqueous layer is charged with motes from which the upper or ethereal layer is free. The motes attach themselves during the shaking by preference to the more aqueous liquid, and thus become separated. When chloroform and water, or chloroform, water, and acetic acid, are shaken up together, the motes collect in the upper or more aqueous layer, even when the composition of the two layers into which the liquids separated was so nearly the same that a few additional drops of acetic acid sufficed to prevent separation altogether. (*Phil. Mag.* [5], xxxiii. 363.)

Other contributions of Lord Rayleigh relating to the conditions of stability of liquid cylinders also appear in the *Philosophical Magazine*. The main outline of the theory of instability of a cylinder of liquid is due to Plateau, who showed that if the equilibrium surface be slightly disturbed the deformation is stable or unstable according as the wave-length λ of the varicosity is less or greater than $2\pi a$, the circumference of the cylinder. The solution of the merely statical question is insufficient, however, for the application to the problem of the disintegration of a jet of liquid, in which in addition to surface tension the action of inertia and viscosity have to be considered.

From a complete investigation of the former of these, Lord Rayleigh has shown that the mode of maximum instability corresponds with $4·51 \times 2a$, exceeding, therefore, very considerably the circumference of the cylinder. Lord Rayleigh now considers the influence of viscosity on the problem. Taking first the more simple case of a thread of a viscous liquid like treacle in contact with a surface of paper, it appears that there is a marked difference between this case and that of a thread the disintegration of which is resisted by true fluid viscosity. The result of the investigation of the latter case is to show that when viscosity is paramount long threads do not tend to divide themselves into drops at mutual distances comparable with the diameter of the cylinder, but rather to give way by attenuation at few and distant places. A separation into numerous drops, or a varicosity pointing to such a resolution, may thus be taken as evidence that the fluidity has been sufficient to bring inertia into play. (*Phil. Mag.* [5], xxxiv. 145.)

Lord Rayleigh further extends the investigation to the case where the inertia of the fluid surrounding the liquid column becomes of importance. In such a case, for example, as the disruption of a jet of air delivered under water, it is the inertia of the fluid outside rather than inside which is important. The result of the investigation shows that the maximum instability corresponds to a longer wave-length in the case of the external fluid than in the case of the internal fluid, as might have been expected from the greater space available for the flow. In a former paper it was shown that for a diameter of 1 mm. the disturbance of maximum instability is multiplied a thousandfold in about a fortieth of a second of time in the case of the internal fluid. If the fluid be external the amplification in the same time would be more than a millionfold. (*Phil. Mag.* [5], xxxiv. 174.)

Finally, it may be noticed that in his discussion of the theory of surface forces (Part III., *Phil. Mag.* [5], xxxiii. 468), Lord Rayleigh arrives at the conclusion that according to the principles of Young and Laplace, the lowering of surface tension due to a very thin film is in proportion, not to the thickness, but to the square of the thickness of the film.

M. Cantor discusses in *Wiedemann's Annalen* (xlvii. 399) the theory and measurement of the capillary constants of electrolytes in contact with metals under different states of polarization of the mutual surface of contact.

Breath figures.

W. B. Croft, in a communication to the Physical Society, gives an account of the methods he has found most satisfactory for the

production of breath pictures on glass. A glass plate, 6 in. square, is put upon the table for insulation: in the middle lies a coin with a strip of tinfoil going from it to the edge of the glass: on this coin lies the glass to be impressed, 4 or 5 inches square, and above it a second coin. It is essential to polish the glass scrupulously clean and dry with a leather: the coins may be used just as they are, or chemically cleansed, it makes no difference. The tinfoil and the upper coin are connected to the poles of a Wimshurst machine which gives 3- or 4-inch sparks. The handle is turned for two minutes, during which one-inch sparks must be kept passing at the poles of the machine. On taking up the glass one can detect no change with the eye or the microscope; but when either side is breathed upon, a clear frosted picture appears of that side of the coin which had faced it. The picture shows a fine gradation of shade to correspond with the depth of cutting in the device. The microscope shows that moisture is really deposited over the whole surface, the size of the water particles increasing with the depth of shade. Around the disc is a black ring, $\frac{1}{4}$-inch broad; sometimes the milling of the coin causes radial lines across this halo. If carefully protected, the figures are permanent; it is possible to efface them with some difficulty by rubbing with a leather whilst the glass is moist. They are not blurred by wrapping in paper. There has not appeared any distinction between the figures made by positive and negative electricity.

When several coins are placed side by side touching one another, there appear in the dark spaces between them well-defined white lines, common tangents to the circular edges of the coins. If these are of equal size the lines are straight; otherwise they are curved, concave towards a smaller coin. They seem to be traces in that plane of the loci of intersection of equipotential surfaces.

A plate of quartz gives the most perfect images; mica and gelatine give poor results. Fairly good impressions can be obtained on metal surfaces, if oiled paper is put between the coin and metal.

Breath figures are also, as is well known, produced by contact and light pressure without the aid of electricity; as is shown in the outlines of coins obtained where the coins have been resting for a while on glass. Paper printed on one side, placed for some hours under slight pressure between plates of glass, gives a perfect breath impression of the print, both from the front and back of the paper. This succeeds best in dry frosty weather. More often both impressions are white, sometimes one or other

or both are black. Threads of wool or cotton give black impressions; silk and copper, white. (*Phil. Mag.* [5], xxxiv., 180.)

The formation of breath figures and a method of projecting them on a screen is described by **Lord Rayleigh** at the end of his article on some of the properties of liquid surfaces alluded to above. The method of production Lord Rayleigh uses is similar to that described above, but in addition to developing the figures by the breath, he shows that they may be developed in a more durable manner by means of a deposit of silver, as in the usual method of silvering glass mirrors chemically, the process being stopped at an early stage. The deposit, after washing and drying, may be protected by a coat of varnish. (*Phil. Mag.* [5], xxxiii. 363.)

F. J. Smith finds that impressions of coins can be obtained by developing photographic plates on which the coins have been laid, and while on the plates have been connected for from 5 to 50 seconds with one terminal of an inductorium or transformer, the other terminal of the inductorium being connected to a metal disc placed below the plate. This method of producing impressions, Mr. Smith calls "Inductoscript." The best results were obtained in an atmosphere of oxygen gas. No picture could be obtained in a good vacuum, and as the pressure increased towards the normal, the picture became more perfect. Good impressions have also been obtained on bromide paper and other papers direct. Pictures can easily be got from woodcuts after they have been well covered with plumbago. (*Proc. Phys. Soc.*, xi. 353.)

Repulsive force of radiating bodies.

P. Lebedew discusses the relation between the repulsion arising from radiation and the Newtonian attraction between two bodies. Taking the simple case of a spherical body which absorbs all the incident radiation, and radiates it then uniformly in all directions, Lebedew makes his calculations by the aid of Maxwell's formula $P = E/v$ (where P is the pressure, E is the energy imparted to the body by the incident rays in unit time, and v is the velocity of light in the medium in which the body is placed) and Langley's value of the constant of solar radiation. Thus the pressure of a pencil of solar rays on 1 sq. metre section at the earth's distance is about $\frac{2}{3}$ of a milligramme. Calling F the resultant force of repulsion and attraction reckoned as a fraction of the force of gravitation with which the body is attracted by the sun, Lebedew obtains $F = 1 - 10^{-4} r\delta$; where r = the radius of the sphere in centimetres, and δ is its density referred to water.

If δ is greater than unity and r greater than 10 metres the deviations from Newton's law must be below the errors of observation of even the most delicate measurements. The smaller r is chosen, the more prominent does the repulsive force of the sun become. In the case of the tails of comets, which are known to consist principally of gaseous hydrocarbons the individual molecules of which, according to Exner, have a density less than 10 and a radius less than 10^{-8} cm., although the formula cannot be strictly applied, since the molecules are neither absolutely black nor large compared with the mean wave-length of the radiation, yet it allows us to suppose that the repulsive force may become several times as large as the attractive, that this ratio may be different for different vapours, and that the repulsive force decreases in the inverse ratio of the distance from the sun. The opinion that the repulsive force of the sun on comets' tails may be sought in its radiation has already been expressed by Faye.

Considering next the case of two absolutely black spheres of radii R and r, and densities D and d, the resultant force due to mutual radiation and gravitation at 0°C. is about $R = 1 - 20\, RrDd$.

If $R = r = 2$ mm., and $D = d = 10$, the two spheres would neither attract nor repel in space. In smaller bodies the repulsion would be in excess. Particles of dust for which r is less than ·001 mm. would repel at 0°C. in space with a force the order of which is a million times greater than that of their gravitational attraction. Passing to still smaller bodies, we come to molecular dimensions, and although the formulæ are no longer applicable, it appears that the forces arising from the reciprocal radiation of molecules cannot be ignored unless it has first been ascertained whether they form an appreciable fraction of the molecular forces. (*Wied. Ann.*, xlv. 292.)

B. Galitzine gives a mathematical discussion of the pressure exerted by radiation in a paper on Radiant Energy in *Wied. Ann.* xlvii. 479.

Velocity of sound in membranous bodies.

F. Melde has made an extensive series of experiments on the velocity of sound in membranous bodies, *i.e.*, bodies which are capable of forming a membrane, or which can be used for all purposes for which membranes can be applied, such as paper, silk, linen, cotton and woollen stuffs, caoutchouc, animal membranes, vegetable tissues, etc. The velocity of sound in such bodies varies greatly, but can be easily determined by fixing narrow strips at the ends, rubbing them in the middle, and determining the pitch of the fundamental note produced. The

strips used were of even breadth, and ½ to 1 metre long. They were fastened in a sort of acoustical bench, and rubbed in the middle between the finger and thumb, which were covered with a kid glove dusted with finely powdered resin. Most substances are thus easily set in longitudinal vibration. In the case of some like oilcloth, which were too smooth, small strips of tissue paper were pasted in the middle of the strip on either side. Amongst papers, yellow tissue paper gives the highest velocity, and blotting and straw papers the lowest, the range being from 1619 to 2705 metres per second. Silk, linen, cotton, and woollen stuffs gave wide differences, ranging from 758 metres to 2015 metres, the lowest being for triple-coloured narrow-ribbed silk ribbon. Caoutchouc and rubber stuffs could not be set in vibration. Vegetable tissues, such as strips of bast and wood shavings, gave very high values, 3159 to 4179 metres. Animal membranes showed great differences, from 1860 metres (parchment) to 471 (red sheep's leather). Metallic strips can also be treated in the same way, but as these are more easily determined in other ways only magnesium strips were tried. These gave a velocity of 4602 metres. (*Wied. Ann.*, xlv. 568, 729.)

HEAT.

By H. H. HOFFERT, D.Sc., Assoc.R.S.M.

THE most noticeable point in connection with the contributions to this subject which have appeared during the year is the great progress which has been made in extending the range of accurate measurements of temperature to very high and very low limits. Prof. Dewar at the Royal Institution, in his researches on the properties of liquid oxygen, has penetrated into the region of low temperatures to points within 70° or 80° C. from the absolute zero of temperature, at which it is probable that the hydrogen air thermometer can no longer be relied upon as obeying even approximately the laws of perfect gases. **Moissan**, by means of a new electrical furnace, has reached temperatures ranging from 2000° to 3000° C. At the latter temperature lime melts and runs like water. (*Comptes Rendus*, cxv. 1031.)

Expansion.

G Melander has made a careful determination of the variation of the coefficients of expansion of air, CO_2, and H, between the temperatures 0° and 100° C., at pressures ranging from about 1 atmosphere to about 5mm. of mercury. According to his results

the coefficient of expansion of air decreases with the pressure till the pressure reaches 232 mm. Below this pressure the coefficient increases with decreasing pressure. Thus the coefficient of expansion at constant pressure at a pressure of 1027 mm. is ·0036660, at 232·2 mm. it is 0036594, and at 9·1 mm. ·0037627. The coefficient of expansion of CO_2 decreases with the pressure to a pressure of about 76 mm., after which it increases. (At 1028 mm. it is ·0037264, at 76·2 mm. ·0036641, at 24·7mm. ·0036753.) The coefficient of expansion of H increases with decrease of pressure, at least as long as the pressure is below the highest observed, 1043·6 mm. (At 1043·6 mm. it is ·0036504, at 12·8 mm. it is ·0037002.) It thus appears that the coefficient of expansion of gases has a minimum which corresponds in different gases to a different pressure. In the case of H it probably lies above 1044 mm. (*Wied. Ann.*, xlvii. 135.)

K. Scheel discusses in *Wied. Ann.* xlvii. 440 the results which have hitherto been obtained for the thermal expansion of water, and gives an account of new determinations of his own. A table is appended to his paper giving the density of water for each degree of temperature from 0°C to 33°C.

The expansion of liquids is also discussed by **B. Galitzine** in *Wied. Ann.*, xlvii. 466, and **G. Melander** (*Beiblätter*, xvi. 414).

E. H. Amagat has published the results of a series of experiments on the laws of expansion of liquids, their comparison with the laws relating to gases, and the form of the isothermals of liquids and gases. The coefficient of dilatation diminishes with increase of pressure, water alone forming an exception. It increases at first regularly with the temperature, then decreases. The isotherms pV are, like those of gases, slightly curved towards the axis of pressures. (*Comptes Rendus*, cxv. 1041.)

Thermometry.

C. T. Heycock has made experiments in conjunction with Mr. Neville on the change in zero of mercury thermometers. By boiling the thermometers for 18 days in baths of either mercury or sulphur the zeros are found to be practically fixed unless they are exposed to higher temperatures than those of the substance in which they were boiled. In the heating, the change in zero is very rapid for the first few hours, but becomes afterwards almost nil as the heating is continued. (*Proc. Camb. Phil. Soc.*, vii. 319.)

E. H. Griffiths and **G. M. Clark** show that if, in accordance with Dewar and Fleming's recent demonstration that the electrical resistance of metals is zero at the absolute zero of temperature, the temperature at which $R = 0$ is calculated on the assumption that Callendar and Griffith's formulæ for finding temperatures by the

variations of the resistance of a platinum thermometer can be extended to very low temperatures, the results of seven different thermometers differ only by a few degrees from the mean value — 273·86°. They conclude, therefore, that the platinum thermometer enables correct measurements of temperature to be made over the range — 273° to + 700°C. (*Phil. Mag.* [5], xxxiv. 515.)

Measurement of high temperatures.

C. Barus, in the course of an investigation of the fusion constants of igneous rocks, has subjected the thermo-electric method of the measurement of high temperatures to a critical examination with a view to test its reliability for accurate work, as the platinum iridium couple has had discredit thrown on it by Le Chatelier. For this purpose he has compared the couple formed of platinum and platinum alloyed with 20 per cent. of iridium with a constant pressure-air thermometer. The apparatus employed comprised a special form of furnace with rotatory muffle for obtaining complete equalisation of temperature round the bulbs, which were made of refractory porcelain of Bayeux, and were provided with capillary stems passing through one axle of the rotating muffle, while the thermo-element was introduced through the other. Barus claims for the constant pressure air-thermometer the unique advantage that it admits of easy modifications whereby the zero of the bulb, its coefficient of expansion, as well as all permanent changes of volume, may be evaluated without the aid of extra appliances. He finds that the platinum-iridium couple is free from serious anomalies, and that the methods he employed were sufficient for the rigorous solution of the calibration problem up to an accuracy of 1° in 1,000°.

A comparison was also made of the thermo-electric forces of a platinum-iridioplatinum and a platinum-rhodioplatinum element within a range of temperature of about 1,700°. Between 340° and 1,220° the ratio of the E.M.F.'s is strikingly constant. The 20 per cent. platinum-iridium element is thermo-electrically stronger than the 10 per cent. platinum-rhodium element in the ratio 100 : 76. Between 1,200 and 1,700 the platinum-rhodium couple gains thermo-electrically on the other, so that the relation is no longer linear, but the change is very gradual and uniformly continuous. The deviation is not large, and may be probably ascribed to disturbing agencies arising from the action of the very high temperatures and the hot gases on the insulators. It may be reasonably asserted that the ratio of the thermo-electric powers of the two couples is probably constant throughout the whole range of 1,700°. Barus therefore claims that the change in E.M.F. of both these elements is thoroughly normal, for if there

were anomalies present they would have to be similar and symmetrically situated in the two couples—a very improbable assumption. (*Phil. Mag.* [5], xxxiv. 1, 376.)

L. Holborn and **W. Wien** have also made an elaborate study of the platinum-rhodium thermo-electric element with reference to its suitability as a standard instrument for the measurement of very high temperatures. By direct comparison of the platinum and 10 per cent. rhodium alloy element with a standard air-thermometer, they find that the relation between temperature and thermo-electromotive force could be represented with close approximation, between the temperatures 400° and 1,440°, by the trinomial function—

$$f(e) = 13{\cdot}76\,e - 0{\cdot}004841\,e^2 + 0{\cdot}000001378\,e^3.$$

The examination of different thermo-elements either made from the same wires or different samples of wire of the same or of different composition, showed that in unfavourable circumstances the Thomson currents in two different elements made from the same sample of platinum wire and the same 10 per cent. rhodium alloy, might amount to an effect equal to the difference of 5° at the highest temperatures. Between rhodium alloys from different sources, but of alleged equal percentage composition, much greater differences occur. With variations in the percentage of rhodium the thermo-electric force considerably increases with the percentage of rhodium at higher temperatures, and from 10 per cent. to 40 per cent. of rhodium the increase is fairly uniform, so that there is no percentage composition which offers special advantages in respect to suitability for the construction of a reproducible standard. During the course of the investigations some melting points were determined, to obtain correspondence with previous measurements of high temperatures. These were—Gold, 1,072°; silver, 969°; copper, 1,082°. (*Wied. Ann.*, xlvii. 107.)

H. Le Chatelier has devised an optical pyrometer suitable for workshop use, in which the temperatures are obtained by photometric measurements of the intensity of the light emitted by the hot body. That sufficient sensitiveness may be thereby obtained is shown by the fact that between the temperatures of 600° and 1,800° the intensity of the red radiation from a black surface increases from 1 to about 1,000,000. To measure photometrically such varied luminous intensities a series of absorbing glasses, which can be superposed in larger or smaller numbers, are used, and intermediate variations between two of the glasses are measured by an iris diaphragm. Le Chatelier has adapted Cornu's photometer to this purpose, and has given it the form of a portable telescope,

which can at will be carried in the hand or fixed on a stand. In front of the eyepiece is placed a piece of red glass, carefully chosen so as to be sufficiently monochromatic without being too deep in colour. The absorbing glasses were specially made by M. Appert of glass coloured with a mixture of oxide of iron and oxide of copper, with a little oxide of manganese and nickel. A candle or small paraffin lamp is used as a comparison light.

The principal difficulty in the use of such a pyrometer lies in the fact that the intensity of radiation emitted by an incandescent body depends not only on its temperature, but also on its chemical nature, physical state of its surface, and the temperature of the enclosure in which it is placed. In the case where it is in equilibrium with its enclosure its brightness is a function of its temperature only, and in the case where its diffusivity is zero (black body) its brightness is independent of the temperature of the enclosure, and depends only on its own temperature. An examination of the emissivities of various bodies has shown that this latter condition is fulfilled by carbon and by magnetic oxide of iron. In other cases it is necessary to have a special graduation for each radiating body. This graduation Le Chatelier has made for a certain number of bodies heated in an air-gas flame, and it appears that the ratio of the emissivity of platinum to that of the magnetic oxide is practically constant at temperatures between 600°C. and 1,800°C. The graduation which has been determined for the magnetic oxide is applicable to all bodies heated in an enclosure at the same temperature as themselves. The following are the emissivities of the bodies examined at temperatures between 1,000°C. and 1,500°C.:—$Fe_3O_4 = 1$; Pd = 0·5; Pt (dull surface) = 0·4; Pt (bright) and Kaolin = 0·25; MgO = 0·1.

Le Chatelier gives some results of measurements of fusion points and furnace temperatures made by this instrument. He finds, for instance, the melting point of cast iron is 1,135° to 1,220°; of steel, 1,410° to 1,475°; brass (35 per cent. of Zn), 880°. The temperature of an incandescent lamp filament is given at about 1,800°C. The effective temperature of the sun, that is the temperature which a body of unit emissivity must have to give radiation of the same intensity as the sun, is estimated at 7,600°C. The actual temperature of the photosphere must of course be much higher than this. (*Journal de Physique* [3], 1, 185; also *Comptes Rendus*, cxiv. 734.)

J. Violle confirms Le Chatelier's values for the radiation from platinum at temperatures up to 1,500° by reference to measurements of his own. Above 1,500, however, there is a disagreement

between the numbers, which Violle attributes to the red glass used by Le Chatelier not being sufficiently monochromatic. (*Comptes Rendus*, cxiv. 734.)

A. Crova has employed an optical method of measuring high temperatures at the Creuzot ironworks for some years, and finds it both convenient and accurate. The method used by Crova consists in measuring by a spectro-photometer the ratio of two photometric determinations of the light emitted by the incandescent body and by a Carcel lamp in two different regions of the spectrum. This method has the great advantage of being independent of the constancy of the lamp and of the emissivity of the incandescent body. The method is extremely sensitive, the smallest variations being detected before an air-thermometer has time to record the change. The optical scale is calibrated by making observations on the radiation from the bulb of the air-thermometer itself, and therefore up to 1,600°, the highest temperature at which the air-thermometer could be used, the scale is directly convertible to centigrade degrees. (*Comptes Rendus*, cxiv. 941.)

Kinetic theory of gases. Dulong and Petit's law of atomic heat.

A memoir on the kinetic theory of gases by **P. A. Leray** appears in the *Annales de Chimie et de Physique* ([6] xxv. 89). In this, Leray defines the quantity of heat of a molecule by the mean kinetic energy of its vibratory motion, and the same expression is taken as its absolute temperature. The temperature of a body is thus the ratio of its quantity of heat to the number of its molecules. A perfect gas is defined as one in which the number of molecules is invariable, and in which the different forms of energy, translation, vibration, and rotation, are in a constant ratio. Leray then develops the kinetic formula by taking account of the effects of impacts and condensation of the molecules.

This definition of quantity of heat leads to the recognition of three specific heats of a gas. The absolute specific heat γ is the increase in the quantity of heat which a gaseous mass whose weight is 1 *kgm.* receives when its temperature augments 1°; the degree Centigrade being defined as the hundredth part of the increase of vibratory energy of a molecule (H_2O) of water in passing from the state of melting ice to that of water boiling under normal pressure. The other two are the ordinary specific heats c and C at constant volume and at constant pressure, which are defined by replacing in the above definition the increase of internal heat by the quantity of external heat absorbed in the elevation of unit weight through 1°. The two

ordinary specific heats are proportional to the absolute specific heat, but their ratio C/c is independent of it. This ratio is not the same for all perfect gases, since the energy of rotation augments with the complexity of the molecule, so that the ratio should be less for gases whose molecules are triatomic and tetratomic than for gases whose molecules are simply diatomic.

It also follows from the primary definitions that the product $\gamma\pi$ of the absolute specific heat and the molecular weight must be constant. The ordinary specific heat C is composed of three parts (1) the absolute specific heat, (2) the work resulting from movement of the molecules or the internal work of disgregation which prepares changes of state, as fusion or vaporisation, (3) the work of dilatation. The first of these quantities is constant, the second and third are variable. Therefore $C\pi$ cannot be a constant. As a fact it varies, according to Regnault, from 5·87 to 6·87. Accordingly, Dulong and Petit's law is only approximately true on account of the predominant character of the first quantity γ. In compound bodies the energy of rotation increases with the complexity of the molecule, and to find $C\pi$ a constant it is necessary to restrict oneself to compounds of the same chemical nature, for which the energy of rotation has sensibly the same value.

In O, H, and N, $C\pi$ is nearly constant, and taking for π the molecular weight, these gases give the same product as simple solid bodies.

L. Natanson discusses the isothermal formula on the assumption that the molecules of a gas are mere material points which exert upon each other certain forces when within a limiting distance R from each other. While within this distance they undergo encounter, and form, while under mutual action, a molecular system. Assuming that the systems of a higher degree of complexity are negligible compared with bimolecular systems, it can be shown that $\frac{3}{2}pv = NE(1 + b/v)$, (where N is the number of molecules and E the mean kinetic energy of a free molecule), an expression similar to those of Van der Waals, Lorentz, and others. In this case, however, b may have values positive, negative, or zero, according as the law of force varies, and may, for a given law of force, change sign at a definite temperature or temperatures. Further discussion leads to the result $p/\rho = Rt\,(1 + T_1\rho)$, where ρ is the density of the medium and T_1 a function of the absolute temperature. If higher systems of molecules, up to the i^{th}, be considered, the expression becomes

$$p/\rho = Rt\,(1 + T_1\rho + T_2\rho^2 + \dots T_{i-1}\rho^{i-1}),$$

which is of the general type suggested by Maxwell and supported by Rayleigh. It would therefore seem that in the proximity of the critical state double and triple molecules are prevalent, while in the proximity of the solid state even the effect of systems containing 8 molecules each may become traceable (*Phil. Mag.* [5], xxxiii. 301.)

E. Heilborn, commenting on the physical signification of the "covolume" b in Van der Waals' equation, points out that, as generally accepted, it is proportional to the space n occupied by the whole of the molecules contained in unit volume, and may therefore be written $b = An$. The constant A is given by Van der Waals as 4, and by O. E. Meyer as $4\sqrt{2}$. To decide this question Heilborn applies the equation of Dorn and Exner $n = (n^2 - 1)/(n^2 + 2)$, where n is the refractive index of gases for infinitely long wave length. This gives for H at 4·4°, A = 5·69; and for ethylene at 101° A = 5·62. The mean is 5·655, which is equal to $4\sqrt{2}$. (*Exner's Rep. der Phys.* xxvii. 369.)

Continuity of liquid and gaseous states.

E. H. Amagat describes some experiments he has made on CO_2 by a method which presents considerable advantages for the determination of the density of the liquefied gas and of its saturated vapour near the critical point. The method of procedure is as follows:—A quantity of gas is liquefied in such a way that the volume of the liquid is, say, a tenth of that of the vapour, and when equilibrium of temperature is arrived at the two volumes are read off. The liquefaction is then advanced so as to increase the quantity of liquid to three or four times its former volume, and the volumes are read afresh. If ΔV and ΔV_1 are the augmentation of volume of the liquid and the diminution of volume of the vapour respectively on passing from the first state of equilibrium to the second, and D and D_1 the densities in the two states, then evidently $\Delta V / \Delta V_1 = D_1 / D$. Also if V and V_1 are the volumes of the liquid and of the vapour during one of the two conditions of equilibrium $VD + V_1D_1 = P$; where P is the weight of the gas operated on. From these two relations D and D_1 can be found. In the neighbourhood of the critical point the instability becomes great, until finally a fixed position of the meniscus cannot be obtained. Amagat has, however, succeeded in reaching 31° C.

The results were plotted in the form of a temperature-density curve. This curve has the form of a parabola, like that obtained by Cailletet and Mathias, the axis of which is slightly inclined to the horizontal axis of temperatures; the upper part of the curve represents the density of the liquid, the lower part that of the

saturated vapour. The locus of the middle points of the chord is rigorously rectilinear; the summit of the curve is much more flattened than that of a true parabola, owing to the extreme rapidity with which the two densities arrive at a common value in approaching the critical temperature. As the measurements were pushed to within a few tenths of a degree from this temperature, it is easy to see from the curve that its two branches pass regularly into one another. The critical temperature of CO_2 was thus found to be 31·35° C.; the critical pressure 72·9 atm., and the density 0·464: results which present as close an agreement as can be desired with those obtained by Amagat's previous tracing of the isothermals. The results were also plotted as in Andrews' diagram in a volume-pressure curve. Amagat finds from this curve that if points are taken on the horizontal parts of the successive isothermals at which the volumes of liquid and vapour are equal, the locus of these points is a perfectly straight line nearly perpendicular to the axis of volumes. In consequence the total volume varies very little. It would be rigorously constant and equal to the critical volume if the line were quite perpendicular. The locus of points for which the ratio of the volumes of liquid and gas is 0·8 does not appreciably differ from a straight line normal to the axis of volumes. If, therefore, a Natterer's tube is filled in such a way as to satisfy this condition, its meniscus would preserve a fixed position at all temperatures. This will be the case if it contains unit weight of CO_2 in a volume equal to the specific critical volume. Amagat finally discusses and confirms the curious property noted by Raveau that under certain conditions in a Natterer's tube an increase in the quantity of the saturated vapour may be accompanied by a diminution of its volume; he points out, however, that this only holds for the case where the constant volume (for a weight equal to unity) is less than the critical volume. (*Journ. de Phys.* [3], i. 288.)

H. Pellat points out that there are two definitions of the critical temperature in vogue -(1) the temperature T_c, which corresponds to the critical point in Andrews' diagram of the isothermals; (2) the temperature t_c, at which the surface of separation of a liquid and its vapour disappears. It has been supposed that these temperatures were the same, but the experiments of Cailletet and Colardeau have shown that t_c is less than T_c, so that at the temperature at which the meniscus disappears the density of the liquid is greater than the density of the saturated vapour. Pellat shows that from the consideration of Andrews' isothermals it can be predicted that the liquid and its vapour persist with unequal densities above the temperature at

which the meniscus disappears. Thus the name "critical temperature" should be restricted to T_c, which is more definite and important than t_c. (*Journ. de Phys.* [3], i. 225.)

In commenting on the above **B. Galitzine** suggests a method of directly comparing t_c and T_c, and points out that Stoletow in a recent memoir on the critical state, has arrived on theoretical reasons at the result that the difference $T_c - t_c$ is equal to 0°·52 C. (*Journ. de Phys.* [3], i. 474.)

Specific heat.

The researches of Regnault on the specific heat of simple and mixed bodies gave for many alloys and amalgams of low melting points a considerable difference between the experimental values and the values calculated according to the law of mixtures from the specific heats of the constituent parts. These experiments were made from 100° C., and Regnault attributes the high values of the experiments to the fact that at 100° these bodies already contain a considerable part of their heat of fusion. Accordingly, **L. Schüz** has made determinations of the specific heats of some alloys and amalgams by cooling them in freezing mixtures and in solid CO_2, and then introducing them into a calorimeter at the temperature of the room. He has also made experiments on the rates of cooling and warming between − 80° C. and 0° C. The temperatures were determined by thermo-elements. Schuz's conclusions are :—(1) For the easily fusible alloys Neumann's law holds when their specific heats are estimated between − 80° and + 20° C. (2) The amalgams Zn_2Hg, Pb_2Hg, 10 per cent. NaAm, and 10·58 per cent. KAm, behave exactly in the same way. The remaining amalgams show an approximation to the value calculated by the law provided the temperature is not below − 40° C. Below − 40 C. a portion of the contained mercury crystallises. (3) Pb and Hg form a combination Pb_6Hg_5. The experiments also render probable combinations between Zn, Na, K, and Hg, but no definite combination between Sn and Hg could be established. (*Wied. Ann.*, xlvi. 177.)

Le Verrier has made experiments on the specific heats of some metals (Cu, Ag, Al, Zn, Pb) at high temperatures, which were measured by Le Chatelier's pyrometer, and has been able to show the existence of singular points analogous to those which Pionchon has found in iron, nickel, and cobalt. The specific heat remains constant for intervals of temperature not in general exceeding 200° C. or 300° C., and then changes abruptly. The variation of the total heat of the body is therefore represented by a broken line, the straight parts of which are joined by parts of a variable curve. In the neighbourhood of the singular points molecular

changes occur, and the state of the body is not a function of temperature only, but depends on the manner in which it has been arrived at. The molecular work which corresponds to the change of state undergoes generally a sort of molecular lag, so that one does not find the same total heat at the same temperature during warming and during cooling. (*Comptes Rendus*, cxiv. 907.)

Heat of solution.

The usual method of determining the heat of solution of a salt in water is by observing the change of temperature of the water produced by the act of solution. This involves, amongst other difficulties, the necessity of an accurate knowledge of the specific heats of water, and of the solution at different temperatures. **R. Scholz** avoids these difficulties by performing the solution at constant temperature in a Bunsen's ice calorimeter. A similar method has also been used independently by Staub in 1890. Scholz directs his attention to the influence of change of concentration on the heat of solution, and seeks to find at what stage the heat of solution becomes constant and the heat of dilution nil. The heat of solution of various salts was measured for dilute solutions; concentrated solutions were not directly measured, but were estimated from the heat of dilution of the given solution, and the heat of solution of the dilute solution. Scholz's results, when compared with those of Winkelmann and Thomsen, show differences greater than can be attributed to errors of experiment, and are probably due to the difficulties alluded to above. (*Wied. Ann.*, xlv. 193.)

The theoretical bearing of Scholz's results is discussed in a paper on the theory of the heat of solution, and on osmotic pressure, by **C Dieterici**, in which he points out that they show that the heat of solution of a given salt increases very nearly proportionately to the number of dissolved molecules, and that if the solutions of NaCl are excepted, the heats of solution of the observed salts are nearly equal at equal molecular concentrations; or in other words, that the heat which is expended on the solution of an equal number of molecules in an equally great bulk of water is nearly independent of the nature of the salt. (*Wied. Ann.*, xlv. 207, 589.)

Thermal conductivity.

A. Berget suggests a method of determining the thermal conductivity of metals which can only be obtained in small quantities, by measuring by optical methods the elongation of a bar af the substance which is heated at one end to a known temperature T, and for the rest maintained in an enclosure at constant zero temperature. By gilding or nickel-plating two similar bars of

different metals the emissive powers are rendered equal, and if the coefficients of linear dilatation of the two metals are known, the ratio of their coefficients of conductivity K is given when the ratio of the elongations has been determined. This ratio can be determined with great precision by a method based on the interference of light. (*Comptes Rendus*, cxiv. 1350.)

E. Jannetaz has made a study by Senarmont's method of the thermal conductivity of a large number of crystalline bodies, and has formulated the following law:—"The axes of greatest thermal conductivity are parallel to the directions of most easy cleavage." In the cases where the crystal possesses several planes of cleavage, these may be considered as adding their actions, giving a resultant of the cleavages, and the law may then be stated thus:—"The axis of greatest thermal conductivity is parallel to the resultant of the cleavages." The law is applicable also to schistose and slaty structures of rocks, which act like true cleavages. But it is necessary not to confound the schistose structure with stratification, nor the cleavage of minerals with planes of separation, which do not have their origin in the structure of the crystal but in the circumstances which accompany its formation. (*C. R.*, cxiv. 1352.)

C. H. Lees has investigated the thermal conductivity of crystals and other bad conductors by placing a disc of the material between the ends of two bars of metal placed coaxially, heating one end of the bars and observing, by means of thermo-junctions, the distribution of heat along them. No relation between the conduction and velocity of propagation of light such as Kundt found for metals could be detected. (*Nature*, xlvi. 385.) Lees also read a paper on the conduction of heat in liquids at the meeting of the British Association at Edinburgh.

Thermal radiation.

J. T. Bottomley, in extension of previous experiments on the loss of heat from metallic wires heated by an electric current, has examined the radiation from two copper globes, used by Macfarlane in 1872 for a similar purpose, both in air at normal pressure and at different degrees of exhaustion. The globes were hung at the centre of a hollow metallic sphere, connected to a Sprengel pump and surrounded with cold water. The rate of cooling of the globes was determined by a thermo-electric junction. The surfaces of the globes were either thinly coated with lampblack or silvered and brightly polished. As examples of the results obtained the following may be given:—With the sooted surface a total loss of heat by convection and radiation of $3{\cdot}42 \times 10^{-4}$ C.G.S. units per sq. cm., per 1° C. of difference of temperatures of globe and surroundings, was observed with a difference

of temperatures of 100° C., and with the surroundings at about 14° C. Under similar circumstances the radiation in a vacuum of half a millionth of atmospheric pressure was about $1{\cdot}40 \times 10^{-4}$. Taking a silvered and brightly polished surface under the same conditions, the loss in full air was $2{\cdot}30 \times 10^{-4}$ C.G.S. units; and with the highest vacuum and brightest polish obtained, it was reduced to $0{\cdot}180 \times 10^{-4}$, with in this case a difference of temperature of 180° C. The loss with 100° C. difference would be considerably less, but is not known experimentally at present. (*Proc. Roy. Soc.*, lii. 162.)

LIGHT.

By H. H. HOFFERT, D.Sc., Assoc.R.S.M.

In presenting the reader with the following summary of the most important of the contributions made to this subject during the year, attention may be drawn to some points of special interest.

The interesting relation which follows from Maxwell's electromagnetic theory of light, that the square of the refractive index of the medium for infinitely long waves should be equal to the specific electric inductive capacity of the medium, has been verified in a few cases, but in others the relation seems to be widely departed from. The researches of Rubens (p. 35) on the dispersion of the infra-red rays have shown that this discrepancy is probably to be ascribed to the inapplicability of Cauchy's dispersion formula to the case of extremely long waves. On the other hand, the direct measurement of the refractive index of the medium for very long waves when made by electrical methods (p. 98 *et seq.*) gives results agreeing well with Maxwell's formula. It is interesting to observe that recent researches all tend to show that water has an extremely high refractive index, between 8 and 9, for very long waves.

A *résumé* will be found at p. 41 of the interesting periodic relations traced by Kayser and Runge between the lines in the spectra of the metals. These relations, first announced for hydrogen by Balmer, and since studied by Rydberg, Johnstone Stoney, Kayser and Runge, Snow, and others, have now been shown to exist not only in the spectra of metals of the alkalis and alkaline earths, but also in a series of other metals, and it has been found that the arrangement of the lines is in close agreement with the chemical properties of the metals.

An account will also be found on p. 43 of the important work of Michelson on the distribution of brightness in the lines of spectra. The very powerful interference method employed by Michelson enables him not only to resolve lines which are quite beyond the power of the best gratings, but also to determine the distribution of light in them. There is no doubt that a most powerful means of research is thus placed in the hands of the physicist.

A considerable number of communications referring to colour and colour vision will be found referred to (p. 52 *et seq.*). Owing to their practical importance, the phenomena of colour-blindness are at present being very extensively investigated.

Special attention may also be drawn to the researches of Prof. Oliver Lodge (p. 59) on the relation between moving matter and the ether which pervades it. Although the results are negative, they make an important step forward in the investigation of an obscure problem.

Sources of light.

F. J. Rogers, as the result of an investigation of magnesium as a source of light, arrives at the following conclusions :—

(1) The spectrum of burning Mg approaches more closely that of sunlight than does the spectrum of any other artificial illuminant.

(2) The temperature of the Mg flame is about 1340°C., but the character of its spectrum is such as would correspond to a temperature of nearly 5000°C. were its light due to ordinary incandescence.

(3) The radiant efficiency is $13\frac{1}{2}$ per cent., a value higher than that for any other artificial illuminant (except, perhaps, the light of the electric discharge *in vacuo*).

(4) The radiant energy emitted by burning Mg is about 4630 calories per gramme of the metal burned, or 75 per cent. of the total heat of combustion, as compared with 15 to 20 per cent. in the case of illuminating gas.

(5) The thermal equivalent of 1 candle-power-minute of Mg light is about 2·4 lesser calories, as against 3·5 to 4·0 for other artificial illuminants.

(6) The total efficiency of the Mg light is about 10 per cent., as compared with 0·25 per cent. for illuminating gas.

(7) Taking into consideration the greater average luminosity of the rays of the visible spectrum of the Mg flame, it is certain that, per unit of energy expended, the light-giving power of burning Mg is from 50 to 60 times greater than that of gas. (*Amer. Journ. of Sc.* [3], xliii. 301.)

Reflection of light.

Lord Rayleigh has previously shown that recently polished glass surfaces have a reflecting power differing not more than 1 or 2 per cent. from that given by Fresnel's formula, but that after some months or years the reflection may fall off from 10 to 30 per cent., and that without any apparent tarnish. In the case of solids the accurate comparison of Fresnel's formula with observation is affected adversely by the effects of greasy contamination, atmospheric disintegration, and the powder used for polishing. Lord Rayleigh has therefore thought it desirable to institute experiments with liquids, of which the surfaces are easily renewed; and the more so since his demonstration that (in the case of water, at any rate) the deviation from Fresnel's formula found by Jamin in the neighbourhood of the polarising angle is due to greasy contamination. (*See* "Year-Book of Science," 1891, p. 32.)

He has therefore designed a photometric method capable of dealing with the reflection from a horizontal surface, and has applied it to the examination of the intensity of light reflected from water and mercury at nearly perpendicular incidence.

The observed reflection found by this method for $6\frac{1}{2}°$ incidence, reckoned as a fraction of the incident light, was 0·02076. Fresnel's formula gives ·02047; thus the refraction actually found was $1\frac{1}{2}$ per cent. greater than that given by the formula. With respect to this disagreement Lord Rayleigh remarks that while it seems to be real, it is too small a foundation upon which to build with any confidence. The reflection from mercury was found to be 0·753. (*Phil. Mag.* [5], xxxiv. 309.)

P. Glan finds that when light, polarised in the plane of incidence, is reflected at an angle of 21° 48′ from a plate of transparent calcite, cut perpendicular to the optic axis, a retardation of phase of 0·549λ occurs, which is considerably more than $\frac{1}{2}\lambda$ as in glass and quartz. (*Wied. Ann.*, xlvii. 252.)

Refraction and dispersion of light.

In an incompleted paper by the late **James Thomson**, communicated to the Royal Society by his brother, Lord Kelvin, a simple explanation is given of the well-known beams or ladders of light seen above and below a lamp flame viewed with partially closed eyelids. They are shown to be due to the refracting watery liquid which accumulates in the entrant corners between the lips of the eyelids and the cornea. This liquid prismoid forms a concave cylindrical lens, by which the rays from the flame are spread over the retina in a vertical line through the image of the

flame. The lower beam is due to the prismoid of the upper eyelid, and the upper beam to that of the lower eyelid. With the eyes partially closed both beams can be seen, but as the lids are opened, the rays from one, or the other, or both, prismoids are intercepted by the iris, and so only one beam, or neither of them, is seen. A similar explanation has, it appears, been given by Prof. S. P. Thompson in his class-lectures to his students, but it does not seem to be very generally known. (*Proc. Roy. Soc.*, lii. 70.)

A method of great simplicity, and at the same time of great accuracy, for the determination of the dispersion of a transparent medium for the infra-red rays has been employed by **H. Rubens** to obtain the dispersion curves of prisms of flint and crown glass, quartz, rocksalt, and fluorspar, as well as of some liquids—water, carbon bisulphide, xylol, and benzol. Rays from a steady bright source of light (a zirconium burner), rendered parallel by a lens, are reflected at 45° from a thin film of air contained between two thick plane parallel plates of glass, and are then concentrated by a second lens on the slit of a spectroscope. The spectrum which is thus produced is crossed by vertical dark bands due to interference. The distance between consecutive bands corresponds to a constant difference of wave-length of the light. The prism of the spectroscope is calibrated within the visible range of the spectrum by the aid of the H lines and of the D line; and by graphic interpolation of the dark bands, the wave-lengths of the successive bands in the visible and ultra-red part of the spectrum can be calculated. By this means a series of refractive indices and corresponding wave-lengths can be found and represented graphically in the μ—λ plane by a series of points whose connection by a curve gives the dispersion curve of the prism. The positions of the bands in the infra-red portion of the spectrum were determined by a bolometer.

The examination of the dispersion curves of the various substances mentioned above reveals considerable differences in the optical behaviour of the substances to the infra-red rays. With the lighter flint glasses and rock-salt the dispersion curve possesses nearly constant inclination to the axis of wave-lengths, as already observed by Langley. On the other hand, quartz, fluorspar, and the varieties of crown glass show distinctly recognisable points of inflection, which are especially strong in borate and phosphate glasses. The dispersion curve of water is noteworthy on account of the extraordinarily small decrease of dispersion with increasing wave-length. But the curves of bisulphide of carbon, xylol, and benzol are the most characteristic.

The distance between the bands decreases invariably with increasing wave-length, so that the refractive index attains more and more to a constant value. For these three substances, therefore, Cauchy's formula with two terms, $\mu = a_1 + a_2/\lambda^2$, where a_1 and a_2 are constants determined by observations on two lines, say F and C, of the spectrum, gives results very closely corresponding with the experiments. In the case, however, of glass, quartz, fluorspar, rocksalt, and water, the application of Cauchy's formula is inadmissible even within the range of observation, and therefore the discrepancies found on comparing the extrapolated values with the square roots of the dielectric constants, cannot be held as evidence against Maxwell's theory. As far as the observations with the three above liquids go, the application of Cauchy's formula to the limit $\lambda = \infty$, is, on the other hand, justifiable; and it is of interest to compare the results with the values for dielectric constants of these liquids as calculated by Hopkinson, Arons and Rubens, and Silow. In the following table, therefore, the value of the refractive index for infinitely great wave-lengths a, and the square-root of the dielectric constant κ, is given for each of the three bodies :—

CS_2	$\kappa = 2{\cdot}67$	$\sqrt{\kappa} = 1{\cdot}63$	$a = 1{\cdot}58$
Xylol	$2{\cdot}35$	.. $1{\cdot}53$	,, $1{\cdot}47$
Benzol	$2{\cdot}20$	,, $1{\cdot}48$	,, $1{\cdot}48$

(*Wied. Ann.*, xlv. 238.)

In the case of two of the bodies examined—rocksalt and fluorspar—the investigation could not be carried very far on account of the small energy of the spectrum in the ultra-red owing to absorption. Accordingly these bodies were re-investigated by **H. Rubens** and **B. W. Snow** with a bolometric apparatus of greatly increased sensitiveness. In the case of rocksalt Langley, who attained to $5{\cdot}3\mu$, found the part from 2 to 5μ straight. Rubens and Snow reached $8{\cdot}3\mu$. Beyond 5μ the straightness is not continued, and the curve inclines upwards. Langley's extrapolation numbers diverge, therefore, more and more widely from truth as λ increases. Sylvin shows very similar behaviour to rocksalt, but the dispersion, which in the visible part of the spectrum is only a little below that of rocksalt, decreases more rapidly with increasing wave-length, so that at 8μ it is only a third of that of rocksalt. Sylvin, therefore, is less suitable than rocksalt when used as a prism, but on the other hand it is more suitable for the construction of lenses for concentrating heat-waves. Owing to the continually increasing dispersion of fluorspar a great decrease of energy occurs, in

consequence of which a wider slit was necessary. With this the wave-length 8μ was reached. The dispersion of this substance decreases to $\lambda = 2\mu$, then again considerably increases, and attains at $\lambda = 8\mu$, a value not greatly below its value in the red of the spectrum. Compared with rocksalt and sylvin the dispersion of fluorspar is very small in the visible region of the spectrum, but in the ultra-red it is very great, so that this substance is eminently suited for the production of prismatic energy-spectra, an advantage which is strengthened by its constancy and the ease with which it is worked. (*Wied. Ann.*, xlvi. 529.)

An extensive investigation of the refraction and dispersion of different varieties of glass and of the influence of temperature on the refraction has been made by **C. Pulfrich** with the aid of samples of 12 different kinds of glass from the Jena glass-works. Observations were also made on quartz, fluorspar, rocksalt, and sylvin.

The result of the observations showed that an increase of dispersive power follows an increase of temperature in all the substances examined. In cases in which the refractive power increases with the temperature, the relative temperature changes are greater in the blue than in the red; in those in which the refractive indices decrease with the temperature the decrease in the blue is smaller than in the red, so that in both cases the spectrum is extended.

The explanation of the effect of temperature on the refractive index is afforded by the consideration of the effects of volume change and increased absorption in the blue. These two actions are opposed to each other; decrease of density diminishes the index, increase of absorption in the blue raises it; according as one or other of these actions preponderates, there is an increase or decrease of refractive index. If both actions balance, the refractive index is independent of the temperature. In glass the action of absorption preponderates, also in crystals with small expansion coefficients. The increase of blue absorption of glass with rise of temperature is in some cases so marked as to be perceptible to the unaided eye, the glass becoming perceptibly yellower. This change is a purely physical one.

The increase of dispersion observed in transparent bodies is, at least for the majority of flint glasses, the direct consequence of an increased absorptive power in the ultra-blue. On the other hand, casual changes of absorptive power in the ultra-red do not affect the middle part of the spectrum. In the case of the remaining substances a decision cannot be arrived at from the changes of inclination of the refraction-curve with changes of temperature as to whether the increase of dispersion originates

from an increase of the ultra-red or ultra-blue absorptive power. (*Wied. Ann.*, xlv. 609.)

D. Shea gives, in *Wiedemann's Annalen*, an account of the examination of the refraction of thin metallic prisms, formed by Kundt's method, of gold, silver, copper, platinum, and nickel, thus continuing the work of Du Bois and Rubens on nickel, cobalt, and iron. In the case of copper, the refractive index μ, which is 0·48 for normal incidence, increases regularly, and becomes unity at an incidence $i = 63°$, after which it increases further to 1·10 at $i = 90°$. In gold $\mu = 0·26$ at $i = 0°$, and becomes unity between $i = 70°$ and $i = 80°$. In silver $\mu = 0·35$ at $i = 0°$, and becomes unity at an angle a little over 70°. In platinum μ increases with the angle of coincidence from 1·99 to 2·19, in nickel from 2·01 to 2·20, in iron from 3·03 to 3·15, and in cobalt from 3·16 to 3·28. Shea discusses the agreement of the observations with formulæ derived from Cauchy's, Helmholtz's, and Voight's theories. (*Wied. Ann.*, xlvii. 177.) The results are also discussed in the same number of the *Annalen* by **H. E. J. G. du Bois** and **H. Rubens** (xlvii. 203), with special reference to formulæ given by **H. A. Lorentz** in the *Annalen* (xlvi. 255), by which the behaviour of metal prisms is elucidated. The theory of the refraction of light in metallic prisms is also discussed by **P. Drude** in *Wied. Ann.*, xlii. 666.

G. Müller, who has made observations on the temperature changes of refractive index of glass, calcspar, and quartz, corroborates Pulfrich's results in so far that in all kinds of glass and in calcspar an increase of dispersion occurs with increase of temperature, which is in general the more observable the more highly refracting the substance is. But in quartz, according to Muller's results, the change of dispersion is inappreciable, and at most is a very small decrease with increase of temperature, while Pulfrich finds an increase of dispersion. (*Wied. Ann.*, xlvi. 260.)

B. Walter gives as the result of remeasurements of the refractive index of water for the D line, between 0°C. and 30°C., the formula—

$$\mu = \mu_0 - 10^{-6}(12t + 2·05t^2 - 0·005t^3)$$

which expresses the results to a very close degree of approximation, the observations on which it is based being probably correct to the fifth decimal place. (*Wied. Ann.*, xlvi. 423.)

A discussion of the refractive indices of dilute solutions, measured by the interference of light method, is given by **W. Hallwachs** in *Wiedemann's Annalen* (xlvii. 380). If v denotes the volume of solution which contains 1 gramme equivalent of the

substance, and Δn the difference of refractive indices of the solution and of water for sodium light, the quantity $v\Delta n$ (molecular refraction change) increases considerably in H_2SO_4; somewhat less in $MgSo_4$, $ZuSo_4$, $CuSo_4$, Na_2Co_3, and tartaric acid; and only slightly in HCl, NaCl, and acetic acid.

Double refraction.

K. Umlauf has made new determinations to investigate the double refraction which can be produced in true liquids by subjecting them to mechanical influences whereby a state of unequal strain is produced. The experiments were made by the double cylinder method, the inner cylinder being rotated by a water motor. The polarised light passing through the narrow space between the cylinders was analysed with a Babinet's compensator. Accurate measures were possible only with moderate velocities of rotation, and with moderately thin solutions. The results showed, as found by Metz, that the double refraction of the colloid bodies experimented on is approximately proportional to the velocity of rotation. It diminishes with rise of temperature, the velocity being constant. The double refraction is positive in the case of tragacanth and cherry gum, negative in the case of gum-arabic, collodion, and gelatine. Thus, the observations of Ambronn and V. von Exner are confirmed, that solutions of tragacanth and cherry gum behave with deformation by shearing stress optically in the opposite way to gum-arabic, collodion, gelatine, and the oils. An addition of a few drops of sulphuric acid to gelatine, whereby the gelatinisation is prevented, diminishes the double refraction, but does not destroy it. The double refraction of rotating solutions of gelatine increases with the concentration of the solution. This law probably holds for all colloids. Experiments were also made on hydrocarbons and other liquids, at low temperatures, with the result that no double refraction was to be found. Glycerine, water and strong sugar solution at 0° C., also showed no double refraction. (*Wied. Ann.*, xlv. 304.)

Absorption and Radiation.

E. L. Nichols and **B. W. Snow** find, as the result of some experiments on the absorption of light by a lens (crown glass), and pair of Nicol prisms, that, although the glass is practically colourless to the eye, it has a selective absorption which commences in the red, the transparency falling off steadily throughout the spectrum, so that for the region beyond G it is only $\frac{3}{4}$ as great as for red light. In the case of the Nicol prisms, however, the transparency throughout the red and yellow is quite uniform, diminishing less

than 1 per cent. between the A and D lines. In the blue and violet, on the other hand, the absorption appears to be relatively more marked in calcite than in glass. (*Phil. Mag.* [5], xxxiii. 379.)

C. C. Hutchins has made an investigation of the radiation of atmospheric air, by which the absolute radiating power of a column of air could be determined at various temperatures. He confirms Tyndall's result that the radiation increases with the humidity of the air, and it appears also to be proportional to the increase of temperature. (*Amer. Jour. of Sc.* [3], xliii. 357.)

In another paper Hutchins attacks the generally accepted opinion that a solution of alum acts as a particularly efficient absorber of rays of great wave-length. By direct experiments on the radiation of a naked gas-jet transmitted through a cell, 0·6 cm. thick, with sides of quartz plates 0·15 cm. thick, filled with water or with alum solution, the water is, if anything, rather a better absorber than the alum solution. Even a well-polished alum-plate 0·37 cm. thick, transmitted 9·7 per cent. of the radiation, as compared with 8·9 per cent. transmitted by water. (*Amer. Jour. of Sc.* [3], xliii. 526.)

Some correspondence on the same subject appeared in the pages of *Nature.* **H. N. Draper** pointed out that the use of the alum cell did not rest on Melloni's experiments, for in these it is shown that the proportion of heat rays transmitted by alum solution is greater than the proportion transmitted by water, in the ratio of 12 to 11. **E. Guillaume** suggested that, assuming that alum and water have absorptive actions over different regions of the spectrum, the solution, by combining the effects of both, may be superior as an absorber to either. **Shelford Bidwell** gives figures showing that when the radiant is a paraffin lamp, and the radiometer a thermopile, plain water is a better absorber than alum solution, and he suggests that the alum solution tradition has been so long accepted simply because it has not occurred to anyone to question it. On the other hand, **T. C. Porter** gives the results of experiments which show the practical superiority of potash alum solution to distilled water in adiathermancy when the electric arc is the radiant, and the recipient a Crookes' radiometer. The liquids were contained in a glass cell. While the unimpeded radiation caused 25 revolutions of the radiometer in about 80 seconds, that through the empty cell required about 127 seconds, through the cell filled with water 413, and with alum solution 21,600 secs. (*Nature,* xliv. 446, 540, 565, and xlv. 29.)

See further on the subject of absorption spectra on page 182.

Line spectra.

H. Kayser and **C. Runge**, whose observations on the periodicity of the lines in the spectra of the elements were alluded to in the "Year-Book" for 1891, have completed their investigation by the examination of the spectra of copper, silver, and gold. They find that in these metals the regularly distributed lines form only a small proportion of the whole number, so that without the analogy afforded by the spectra of other metals, it might have been thought that the distribution of the lines was without any system.

Kayser and Runge have combined and compared the results of their examinations of the various spectra. With the exception of Au and Ba they have been able to prove the existence of series of lines, the oscillation frequencies of which are satisfactorily represented by the formula $A - Bn^{-2} - Cn^{-4}$, where A, B, C are positive constants and n represents integer numbers. B has nearly the same value for all the series of the different spectra. A is the limit towards which the oscillation frequency tends when n increases.

The elements arrange themselves in homologous divisions as follows:—

A. Lithium, Sodium, Potassium, Rubidium, Cæsium.
B. Copper, Silver, Gold.
C. Magnesium, Calcium, Strontium.
D. Zinc, Cadmium, Mercury.
E. Aluminium, Iridium, Thallium.

In the first two and in the last group the series consist of doublets, except lithium, whose lines are all single. In the remaining groups, C and D, they consist of triplets. In division A each element possesses three series, a very strong principal series, and two secondary series, of which the first, however, possesses lines less sharp than the second. Each member of each series consists of a pair of lines, the oscillation difference of which is constant in the secondary series, but decreases in the principal series in the direction of decreasing wave length in the inverse proportion of n^4. With increasing atomic weight the series become weaker, and apparently in consequence of this the weaker secondary series cannot be detected in the spectra of rubidium and cæsium.

In the first two members of division B the secondary series of pairs of lines have also been found, but in gold no series could be found, probably for a reason similar to that in the case of rubidium and cæsium. Each element of this division possesses in addition in the ultra-violet a very strongly reversed pair with the oscillation

difference characteristic of the element. These lines are the strongest of the whole spectrum. It is doubtful whether these can be regarded as the first member of a principal series, or whether they are only an isolated pair which correspond to the isolated lines of division D.

Division C comprises the alkaline earths. Their spectra possess two secondary series, whose members are formed of triplets. The series recede, as generally in all the divisions, with increasing atomic weight towards the red end of the spectrum, and become at the same time weaker. For this reason, perhaps, no series have been found in barium, which should be the last element included in this division. A principal series does not exist in this group.

In division D the metals have spectra, which possess two series of triplets as in division C, and no principal series. On the other hand each element differs from those of C in possessing a very strong, broadened, and reversed line in the ultra-violet, the strongest of the whole spectrum.

It is thus seen that the elements fall spectroscopically into the same divisions as are formed by their chemical properties. It is interesting to note that magnesium appears more nearly related to calcium and strontium than to zinc, cadmium, and mercury.

The doublets and triplets in each group broaden as their atomic weight increases. In group A the difference of oscillation frequencies is nearly proportional to the square of the atomic weight. (*Wied. Ann.*, xlvi. 225; also *Nature*, xlv. 607.)

A full account of **Johnstone Stoney's** analysis of the spectrum of sodium, and his theory of the origin of the double lines referred to in the "Year-Book" for 1891, appears in the *Trans. Roy. Dublin Soc.* iv. 593; also in *Phil. Mag.* [5], xxxiii. 503.

A discussion between Runge and Stoney on the application of Fourier's theorem to the discussion of this theory has been carried on in *Nature*, xlvi. 29 *et seq.*

B. W. Snow has made an important investigation of the ultra-red emission spectrum of the alkalis by Rubens' bolometric method described above (p. 35). The investigation was undertaken with the special object of testing the applicability of Kayser and Runge's formulæ for the groups of spectrum lines of these metals to the region beyond the visible red of the spectrum. The energy spectra of the electric arc and of the alkaline metallic salts are mapped in a series of plates accompanying the paper. It appears from the curves that the A line of potassium, although weak in visibility, is the strongest in absolute radiant intensity of all the lines of the five metals Li, Na, K, Cs, and Rb, which

were examined. On comparing his results with the wave-lengths of the ultra-red lines calculated by Kayser and Runge, by extrapolation by their empirical formulæ, Snow finds a close agreement in the case of Li and Na, but in the other metals the divergences are more considerable, so that the results cannot be at present regarded as confirming the formulæ of Kayser and Runge. (*Wied. Ann*, xlvii. 208.)

A very interesting and important application of interference methods to the investigation of the distribution of brightness in the bright lines of spectra has been made by **A. A. Michelson**, who shows the great advantages which may be expected from a study of the variations of clearness or visibility of interference fringes with increase of difference of path of the interfering pencils. With the best instrumental appliances now in use it is difficult to resolve lines as close together as the components of either of the two yellow sodium lines. With the interference method, or "light wave analysis," Michelson shows that a tenth of this distance is well within the limit; indeed, if the width of the lines themselves is less than their distance apart there is no limit.

The method consists in allowing the light from the approximately homogeneous source in which the distribution of light is to be determined to produce interference fringes, with any form of interference apparatus which allows a considerable alteration of the difference of path of the two interfering streams of light. In the apparatus actually employed, the light from a vacuum tube containing the substance whose radiations were to be examined was formed into a spectrum, from which the required radiation was separated from the rest by allowing it to pass through a narrow slit. The light from this slit was rendered parallel by a collimating lens, and then allowed to fall on a transparent film of silver on a plane parallel plate of glass. Here, by reflection and transmission in approximately equal proportions, it is divided into two mutually perpendicular portions, which are reflected normally back by two plane mirrors to the silver film, and there by partial transmission and reflection again two coincident pencils are sent into the observing telescope. When the two mirrors are equally distant from the silver film the difference of path of the two interfering streams is zero; and it can be increased to any amount required by moving one of the mirrors away from the film. In this way interference fringes can be obtained in the observing telescope in the form of concentric circles whose visibility is a maximum when there is no difference of path between the interfering streams. With a gradual increase in the difference of path the visibility of

the fringes undergoes variations more or less marked according to the way in which the light in the source is distributed. By measuring the visibility for every 2 mm. difference of path a visibility curve can be constructed, and from the form of this curve Michelson shows how it is possible to calculate the curve of distribution of light in the source as a function of wave length.

From these results, and the curves which accompany them, it can be seen that it is easy by this method to separate lines whose distance apart is only a thousandth of that between D_1 and D_2, and even to determine the distribution of light in the separate components. The conditions most favourable to high values of the visibility are low density and low temperature. High pressure and density broaden the spectral lines and diminish the visibility, the one acting by altering the period of the source by frequent collisions, the other by the change in the wave-length of the light due to the motion of the source in the line of sight. (*Phil. Mag.* [5], xxxiv. 280.)

Michelson's work is commented on by Johnstone Stoney in *Nature* (xlvi. 513), and by Lord Rayleigh in the *Phil. Mag* [5], xxxiv. 407.

G. D. Liveing discusses Plücker's supposed detection of the line spectrum of H in the oxyhydrogen flame, which has never been confirmed or disproved, although important inferences as to the condition of the solar atmosphere and other matters have been drawn from it. Liveing, after an exhaustive series of experiments, has come to the conclusion that the temperature of the oxy-hydrogen flame is insufficient to cause H to emit the rays we see produced in the electric discharge in that gas, and that Plücker must have mistaken some other rays for those of H. (*Phil. Mag.* [5], xxxiv. 371.)

E. Pringsheim has made a series of experiments to test whether the radiation of gases is due to rise of temperature only, or is to be ascribed to other causes. Attempts were made to bring Na into the luminous state by simple heating, with exclusion of combustion or other chemical changes. The substance was heated in the middle part of a long unglazed porcelain tube, whose ends were closed by glass plates kept cool by a water jacket. When $NaCO_3$ or NaCl were thus heated in an atmosphere of air, N, or CO_2, neither in the emission nor absorption spectrum was any trace of the sodium line to be observed, even at the highest attainable temperatures. The line was first observed when metallic sodium was used, but in this case it was traced to oxidation of some of the sodium.

Experiments were then made on "cold flames." By burning a mixture of CS_2 and air a flame can be produced, the temperature of which can be reduced so low that the finger can be held for some time in the flame. The light is of small intensity, but exceedingly blue. The temperature at the warmest place was below 150°. The flame shows a continuous spectrum weaker in the red than in the blue and violet, and it cannot be questioned that the gases emit radiation in consequence of chemical processes and not of their high temperature. By increase of the quantity of CS_2 the temperature of the flame can be raised, and at a temperature of 1322° to 1357° sodium begins to be luminous in the flame. The temperature at which sodium was luminous in the tube was 1050° to 1080°. Pringsheim concludes that it may be considered proved by these experiments that sodium salts in flames emit the characteristic light of sodium at temperatures at which by simple rise of temperature in a neutral gas they show no trace of luminosity, and that on the other hand metallic sodium heated in a furnace in a neutral gas emits the same radiation as sodium salts in flames.

When hydrogen was substituted for the air, N, or CO_2, in the porcelain tube, the emission and absorption spectrum were clearly produced. The sodium salts were luminous in this case on account of chemical reduction. The reduction could also be produced and the spectra obtained by other means, such as by scraps of unglazed porcelain, carbon, iron, etc. These experiments show that the radiation of sodium salts is produced by reduction, and that in the Bunsen flame the reductions are brought about by the action of the illuminating gas itself.

Pringsheim concludes therefore that sodium salts in flames and metallic sodium heated in neutral gases shine only in consequence of chemical processes (reduction). The supposition that gases can shine through mere rise of temperature is a hypothesis necessitated neither by experimental nor by theoretical grounds.

With respect to the bearing of this on Kirchhoff's law, Pringsheim remarks that while there is no experimental foundation for the assumption that gases can become luminous by heat alone, a theoretical foundation may be sought in Kirchhoff's law, since this has been established for temperature radiation only. But the experiments show that a complete parallelism between radiation and absorption exists in cases in which the radiation arises solely, or at least in greater part, from chemical processes, in which the presuppositions of Kirchhoff's law are certainly not fulfilled. This is explained very simply by considering that this parallelism is only a qualitative confirmation of Kirchhoff's

law, and that this qualitative agreement of absorption and emission for each kind of radiation follows directly from the principle of resonance. Pringsheim concludes that there exists no gaseous source of light which satisfies the stipulations of Kirchhoff's law. (*Wied. Ann.*, xlv. 428.)

G. D. Liveing and **J. Dewar** have studied the spectra of the flames of two metallic compounds, nickel carbonyl and zinc ethide, to investigate the question whether the vibrations which give the spectra of compounds in flames originate from the effect of high temperature only, or from the energy of chemical changes. The flames of substances into which metals enter as chemical ingredients have not hitherto been observed. (*Proc. Roy. Soc.*, lii. 117.)

Phosphorescence.

A very convenient form of phosphoroscope with electric spark illumination has been devised by **P. Lenard**. The primary coil of a Ruhmkorff's inductor is connected with a mercury interruptor and a battery; the secondary to a Leyden jar of such size that strong spark discharges 5 to 10 mm. long are obtained between the terminals, which are made of zinc. On the vibrator of the mercury interruptor is fixed a light arm of wood 50 cm. long, which carries at its free end a piece of stiff black paper, 4 cm. by 8 cm. in size, fixed so that when the vibrator is in action the paper oscillates vertically in its own plane 10 cm. up and down. As close as possible behind this is the spark gap in a position such that the sparks pass when the upper edge of the moving paper screen is in its downward motion just passing the spark gap. The room being darkened, the eye is placed so that the direct view of the sparks is just hidden by the edge of the descending paper screen. The paper thus appears as a dark stationary body on a somewhat illuminated background. On bringing behind the paper and sparks a phosphorescent body, such as a piece of glass tubing, the body is not hidden by the apparently fixed paper screen, but shines clearly through the screen by its green phosphorescent light. The appearance is as though the paper was transparent only to phosphorescent light. In reality the paper conceals the objects behind it while the spark illuminates them, but immediately again exposes them to view, and so allows the phosphorescence to appear.

The sensitiveness of this phosphoroscope is said to be equal to that of Becquerel, and it has the advantage over Becquerel's phosphoroscope of not requiring sunlight. This sensitiveness is due to the extreme richness of the zinc spark in the invisible rays which excite phosphorescence. (*Wied. Ann.* xlvi. 637.)

G. Salet has tested Stokes' law, according to which the rays

emitted by a fluorescent body are always of less refrangibility than the rays which excite the refrangibility. A spectroscope, preferably with quartz fittings, forms a real spectrum, which is received on the quartz cell of a Soret's eyepiece containing the substance to be examined. The image of this spectrum is projected by a lens transversely on to the slit of another spectroscope. In this is seen clearly the diagonal spectrum of Stokes' classical experiment. No ray, even with Magdala Red, exceeds the theoretical limit. Salet connects the law thus verified with the second law of thermodynamics, and shows that it is a consequence of the fact that heat cannot pass of its own accord from a cold body to a hot one. (*Comptes Rendus*, cxv. 283.)

Interference of light.

A general discussion of the interference phenomena to be observed with two plane parallel plates, and of the interference phenomena in Newton's rings and other lens combinations by **E. Blasius**, appears in *Wiedemann's Annalen* (xlv. 316 and 385). The interference effects produced by two plane parallel plates had previously only been minutely examined for the case where the light is reflected in the same plane from both plates. Blasius discusses the more general cases, and arrives at formulæ for the distances between the bands for various angles between the plates and for unequally thick plates. These formulæ have been tested by **E. Schmidt**, who establishes their validity. (*Wied. Ann.*, xlvi. 1.)

Contributions to the theory of the visibility and orientation of interference fringes are also made by **C. Fabry** and **Macé de Lepinay** (*Journ. de Ph.* [2], x. 5), and **C. Fabry** (*Journ. de Ph.* [3], i. 313); and on the visibility of Newton's rings when formed between a prism and lens by **M. G. Meslin** (*Journ. de Ph.* [3], i. 332.)

Diffraction.

Hermuzescu describes some effects of diffraction obtained by examining by Gouy's method, but with a much more strongly magnifying microscope, the fringes formed by a very carefully worked sharp and straight metallic edge in a parallel beam of light. Outside the limit of ordinary diffraction, and within the geometrical shadow, a luminous band whose dimensions increase with the magnifying power of the microscope is observed in the dark field of view. By careful adjustment of the microscope, this band is seen to be traversed by extremely fine black lines, parallel to the border of the screen. These minima are observable under all deviations, and their colour varies with the deviation.

The colours of greater wave-length become predominant when the deviation or the thickness of the edge increases. The colouration depends on the nature of the metal forming the screen. With copper the colour is red as soon as the deviation reaches about 40°; with brass it is orange-red. Steel gives less definite tints, and zinc a slightly bluish tint. The diffracted light within the geometrical shadow is partially polarised in a direction parallel to the edge of the screen. This polarisation becomes complete with a deviation of 100°. If the incident light is polarised in a direction parallel or perpendicular to the edge, the diffracted light remains so likewise; but if the incident light is polarised obliquely to the edge, the diffracted light is elliptically polarised, and as the deviation increases the ellipse becomes more and more elongated, and its greater axis tends to set itself perpendicularly to the edge.

Sensibly the same effects were obtained with dielectric screens (ebonite and vulcanised fibre), but the polarisation was less complete and the elliptic polarisation could not be observed. These phenomena are not explicable on Fresnel's theory, at least on the assumption that the phenomena are due to refraction at the extremely thin edge of the screen. On this supposition the elliptic polarisation can be accounted for on MacCullagh's theory, and the experimental facts of Faraday, that light refracted by thin metallic films is elliptically polarised. In the electro-magnetic theory the explanation is easier, as Poincaré has shown for the case of screens formed from perfect conductors. (*Comptes Rendus*, cxiv. 465.)

Rotatory polarisation.

E. Bichat describes an interesting experiment illustrative of the production of the phenomena of rotatory polarisation. It is well known that the dielectric between the two plates of a flat condenser which is electrically charged behaves as a doubly refractory crystal, the axis of which is parallel to the lines of electric force. If, then, a series of small condensers are placed in a dielectric liquid, such as carbon bisulphide, and arranged one after the other so that the lines of force make angles which successively differ by a constant amount, the lines of force of the last condenser being parallel to those of the first, a symmetrical pile is formed, analogous to the pile of mica plates of Reusch. To practically realise this pile, and to fulfil the further condition that the angle between the lines of force of successive condensers shall be indefinitely small, Bichat unites all the elementary condensers into a single condenser, the armatures of which are made in the form of conoids. When this condenser is charged,

a rotation of the plane of polarisation is produced in light which passes between its coatings, which is in the same direction as that in which the lines of force successively turn, and which can be compensated by a solution of sugar of suitable thickness. The rotation which was obtained by a given difference of potential of the plates of the condenser agreed well with the value calculated theoretically from Kerr's constant. (*Rev. Gen. des. Sc.*, iii. 548.)

Direction of the vibrations in polarised light.

P. Drude and **W. Nernst**, as part of a general inquiry on the questions whether (1) stationary light-waves produce maxima and minima of modes of action, and whether (2) the maxima and minima of action for one and the same stationary wave coincide for the kinds of action in question, have made an experimental investigation of the fluorescent action of stationary light-waves. It was necessary to produce a film which while fluorescent should have a thickness of only a small fraction of a wave-length. This was accomplished by means of a solution of gelatine (1 : 600) containing, before drying, fluorescein in the concentration 1 : 500. With this films of from $\frac{1}{20}$th to $\frac{1}{30}$th of the mean wave-length of white light were easily produced. From the experiments the conclusion is drawn that *stationary light-waves have maxima and minima of fluorescent action*, and that the *maxima of the fluorescent action of stationary light-waves coincides with the maxima of their photographic action.* To render this result certain, experiments were made with waves which, as in Wiener's experiments, intersected at right angles. Of the two bands incident on the gelatine film, only one showed dark bands, while the other was quite clear. *That image produced bands in the fluorescent light in which the plane of polarisation coincided with the plane of incidence.* Further observations showed that *that light-vector, in the ventral segment of which the maximum of fluorescence lies, vibrates transversely to the plane of polarisation.* The authors also advance theoretical reasons for coming to the conclusion that *it is also probable that the heating effect of stationary light-waves coincides with the fluorescent and photographic effects.* (*Wied. Ann.*, xlv. 460.)

Chemical action of light and colour photography

G. Lippmann has been continuing his researches in photography in natural colours, with the view to improvements in the sensitiveness of the photographic films and in their orthochromatism. This he has succeeded in doing by using albumen bromide of silver films, rendered orthochromatic with azalin and

cyanin. With these films he obtains brilliant photographs of spectra, in which all the colours, even the red, appear at once without the use of coloured screens, and after an exposure varying from five to thirty seconds. On two of the plates obtained by him the colours seen by transmission are very plainly complementary to those seen by reflection. In others, diverse objects such as a stained-glass window, a group of draperies, a plate of oranges surmounted by a red poppy, a many-coloured parrot, are faithfully represented both in form and colour. The draperies and the bird required from five to ten minutes' exposure to the electric light or sunlight. The others were obtained after several hours' exposure to diffused light. The green of foliage and the grey of the stone of a building are perfectly produced on another plate, but the blue of the sky is shown as indigo. There remains, therefore, much still to be done in increasing the sensitiveness of the film and in perfecting its orthochromatism. (*Comptes Rendus*, cxiv. 961.)

In a subsequent communication Lippmann shows that bichromated albumen or gelatine films can be impressed with an image in the same way as the haloid silver films. The image is, however, only visible when the film is moist, as its production depends on the differences in refraction of light thin layers of the film, alternately absorbent or non-absorbent of water. When the films are dry no image is visible. In the case of bichromated gelatine simple breathing on it suffices to bring out the coloured image. (*Comptes Rendus*, cxv. 575.)

H. Krone communicates some conclusions to which he has been led by an attempt to photograph the solar spectrum and the spectrum of the arc-light after the method of Lippmann. He finds that the first essential for the success of the experiment is a completely homogeneous film and a reflecting surface in contact with it, the reflected rays of which interfere with the directly incident light and produce stationary waves in the film. If the film is too thick, either the colours do not appear at all, or they are changed to a different wave-length. Thus at places in the film where dust-particles have produced comet-like markings in the film of irregular thickness variegated colours are seen. The faithful and locally-correct rendering of the colours of the spectrum is not absolute, but only relative, and depends especially on (1) exact accord between the finely-divided haloid silver in the film and the colour sensitiser and its application, (2) the degree of warmth in drying the film, (3) the duration of exposure, and (4) the development. The waves of the incident rays will only give rise to waves of the same length on the fulfilment of completely

definite conditions in the stationary waves produced by their interference. If these conditions are not present, other colours appear. A larger or smaller quantity of moisture remaining in the film affects the result. Also that the spectrum colours should all be simultaneously and satisfactorily represented, the sun must not be too near the horizon. When the illumination is sufficiently strong, the ultra-red rays outside the line A, which are invisible to the eye, appear in the photograph as dark purple; the ultra-violet outside the H group as yellowish rosy-red lavender. Within this ultra-violet part there appears in the spectrum of the electric arc a highly-intense maximum of light, separated from the H lines by a colourless group of carbon lines. With sufficient intensity of illumination this appears deeper and more intensely dark-blue than the indigo-blue of the solar spectrum. The direct comparison of the actinic intensity of the light of the electric arc which was used, when the arc was at a distance of 36 cm. from the slit of the spectroscope, and direct sunlight at midday in the middle of April, with a clear sky, gave a ratio of 1 to 38 or 40.

Krone states that he considers that only by the use of the mercury-mirror, as used by Lippmann, is it possible to represent all the colours in the photograph of the visible spectrum simultaneously and in their proper positions. He has succeeded in photographing the spectrum without the mirror, which was replaced by black velvet, by utilising the to-and-fro reflections from the inner sides of the glass plate. As the reflective action is not so intense, longer illumination is required, and, owing to spreading by repeated reflection, the colours are not as pure as when a mirror is used, except in the blue, violet, and ultra-violet. This action takes place also when the mirror is used but is overpowered by the stronger action of the mirror. Still, it must tend to render the colours less pure, especially if the duration of illumination is much prolonged. (*Wied. Ann.*, xlvi. 426.)

M. Carey Lea has previously shown that AgCl and AgBr could be acted upon by heat, mechanical force, electricity, chemism, as well as by light, so as to form an invisible image capable of development. It had not, however, been shown that mechanical force was capable, like the other actions named, of disrupting the molecule without external aid. This he has now shown to be possible, and thus it may be concluded that any form of energy is capable of disrupting the molecule. The experiments consisted in subjecting AgCl, AgBr, and AgI, both to simple pressure and to shearing stress. In the former case the salt, prepared and washed in non-active light, was subjected to a pressure of

100,000 lbs. per square inch between pieces of platinum foil, and became thereby changed in colour to deep greenish-black. The platinum foil remained bright. In the latter case the salt was triturated for some time in a mortar, and became changed in colour to the familiar chocolate-purple tint, very different in appearance from the greenish-black colour produced by pressure.

The thermochemical relations of silver have been shown by Berthelot to be endothermic. Thus an endothermic reaction can be brought about by simple pressure. (*Phil. Mag.* [5], xxxiv. 46.)

H. M. Elder has made an attempt to apply thermodynamical reasoning to the action of light on silver chloride. Assuming that the pressure of the liberated chlorine is a function of the illumination or intensity of light falling upon the chloride, in the same way as the pressure of a saturated vapour is a function of the temperature, the chlorine in the presence of silver chloride and protochloride is regarded as the working substance in a "light engine," and a Carnot's cycle is performed on the substances at constant temperature, the variables being p, v, and the illumination. As this cycle is analogous to Carnot's, except in the change of illumination for temperature, it is inferred that the efficiency is a function of the illumination. Thus the cycle may be applied to determine an absolute scale of illumination. (*Electrician*, xxviii. 545.)

Colour and colour vision.

The council of the Royal Society in 1890 appointed a committee, of which Lord Rayleigh was chairman and Captain Abney the secretary, to consider the question of testing for defective colour vision. The committee have presented their report, and in it they give as the result of the inquiry a series of twelve recommendations for the proper testing, both for colour and form, of all candidates for employments "the filling of which by persons whose vision is defective either for form or colour, or who are ignorant of the names of colours, would involve danger to life and property." In setting forth the reasons on which the recommendations were based, the committee enter somewhat fully into the characteristics of congenital colour-blindness, colour-blindness produced by disease or injury, and defective colour-vision.

In discussing the explanation of such cases, the committee consider two theories, the trichromatic theory or Young-Helmholtz theory, and the theory of Hering, but without coming to any decision between them, as both theories present difficulties. A suggestion is offered that the action of light on the retina is to produce chemical changes in the condition of certain substances in the retina having different ranges of sensitiveness to light

vibrations. If it be conceded that the retinal substance acted upon by light is a mixture of three analogous compounds, each having a maximum sensitiveness at a different point of the spectrum, the three fundamental sensation-curves of the Young-Helmholtz theory can be accounted for.

The report also contains an account of the examination of various methods and apparatus for testing colour-vision, and of the evidence given by experts in colour-vision testing. The committee consider that the tests of the Board of Trade and the method of applying them are necessarily open to the gravest objection. Very few of the railway companies have any adequate system of testing. The tests carried out by the Royal Navy are, however, most efficient. The test of colour-vision recommended is that of Holmgren, the set of wools being approved by a central authority before use, especially as to the correctness of the three test colours, and also of the confusion colours. If this test be satisfactorily passed, it should be followed by the correct naming of colours such as are employed for signals or lights, and also white light. The tests for form should be those of Sneller, carried out as laid down in one of the appendices to the report. (*Proc. Roy. Soc.*, li. 381.)

W. Rutherford, in the presidential address in the section of biology at the British Association meeting at Edinburgh, reviews the various theories which have been advanced to account for colour-vision, and criticises them with respect to the phenomena of colour-blindness and contrast colours.

In answer to the inquiry, Do the nerve impulses arise from mere vibration, or from chemical change in the molecules of the nerve terminal, Rutherford considers that the photo-chemical hypothesis has much in its favour. The difficulty of total colour-blindness may be met by supposing that colour-perception has not been developed in the corresponding portion of the vision centre, while partial colour-blindness is due to the defect of that one of the substances in the retinal structure which by its decomposition gives rise to the missing colour sense.

W. de W. Abney discusses the subject of colour-blindness in a lecture to the Society of Arts. He describes the phenomenon of colour-blindness on the Young-Helmholtz hypothesis, and explains cases of monochromasy by reference to the unequal extinction of different kinds of light when reduced in intensity. (*Jour. Soc. Arts*, xl. 676.)

W. Pole, whose observations on his own case of colour-blindness were amongst the first that were accurately made, has communicated to the *Philosophical Magazine* some supplementary

details in completion of his former paper, published in 1859 in the *Phil. Trans.* In this he describes the results of examination of four cases of dichromic vision, and some indirect evidence as to the well-known case of Dalton. To represent the impressions received in dichromic vision, Pole constructs, after the Newton-Maxwell method, a colour-map built on a fundamental triangle, at the corners of which are the two primary dichromic sensations, which Pole calls yellow and blue, and the sensation of their equilibrium, white. A fourth point in the same plane is then found to represent their negation, black. The nature of any sensation can then be represented by a point on the map and its relations to the primary sensations made evident graphically. Dr. Pole also describes the dichromic view of the spectrum. In his own case the spectrum is not shortened at either end; it is coloured most vividly, the one division being occupied by various modifications of his less refrangible colour, yellow, and the other division by precisely similar and symmetrically arranged modifications of his more refrangible colour, blue.

The colours gradually merge into each other, becoming fainter and paler as they approach the neutral point between them. The neutral point, which is not a distinct line or colourless band, is situated at about the wave-length 500 (blue-green) in Pole's case, but it varies somewhat for different persons, and even for the same person with different lights. Outwards from their maximum the colours diminish in luminosity gradually, but retain their saturation fully to the end. The high saturation of the dark yellow gives so novel an effect as to lead dichromic patients to believe they see a third colour there. This error was fallen into by Dalton, and was the cause of the long delay in the general reception of Herschel's dichromic interpretation. (*Phil. Mag.* [5], xxxiv. 100.)

In a second paper **Dr. Pole** gives an account of Donders' theory of colour-blindness, which, although published in 1880, is still but little known in this country. Donders considers that our natural impressions point to four "simple" colours—red, yellow, green, and blue; but he believes these sensations are caused by the combinations of three more highly-saturated "fundamental" energies corresponding to red, green, and violet. In the various forms of colour-blindness there is no reason for supposing that the colours wanting are the fundamental ones of the normal system. The retina is an organic whole, in which one of the three activities cannot be absent without the defect having an influence on the other two. Therefore, dichromic vision does not

consist simply of two of the energies of trichromic vision. Donders considers that the examination of colour-blindness proves that the white light of the colour-blind is neutral, colourless, and that their two colours, warm and cold, are complementary. In red-blindness the colours are yellow, inclining towards green and violet; and in green-blindness, yellow inclining towards red and blue.

Donders puts forward a theory of colour-vision which is based on the evolution of the colour-sense. In the normal eye full colour perception exists only in the central portions of the retina; around this is a zone which is dichromic, and outside this total colour-blindness. These are held to represent successive stages in the development of colour-seeing power, viz. (1) a chromic vision of light and shade only; (2) dichromic imperfect vision, with shortened spectrum, and low sensitiveness to the long-waved rays (red-blindness); (3) dichromic perfect vision with longer spectrum and full sensitiveness to the long, waved rays (green-blindness); (4) trichromic vision with low sensitiveness to certain colours; (5) trichromic perfect vision. Thus colour-blindness is on this view only an imperfect development of normal vision. (*Phil. Mag.* [5], xxxiv. 439)

A. König and **R. Ritter** have made an attempt to obtain curves of the distribution of brightness in the spectrum for each of several degrees of brightness, both for their own eyes, one normal trichromic (K) and one red-blind (R), and for those of some other observers. The comparisons were made against a constant surface which contained light of the wave-length 535 $\mu\mu$ (thallium green). The lowest degree of illumination was such that the observer had to be at least a quarter of an hour in absolute darkness to perceive it at all. The brightest was 262,144 times as great, corresponding for K's eye to the illumination of a white-paper surface by 600 candles, one metre off when viewed through a diaphragm of 19 mm. aperture. The principal results obtained by the various observers are summed up in the following statements, in which all the data refer to the dispersion spectrum of gas-light.

(1) For all observers, trichromic, green-blind, and red-blind, the curve of brightness had almost exactly the same form for the darkest shade, and it was that which has been observed by Donders, Hering, Dieterici, and König, for greater degrees of brightness in congenital monochromacy. Its maximum was at 535 $\mu\mu$.

(2) As the brightness increases, the wave length of the maximum increases with trichromic vision at first slowly, then

more rapidly, and finally slowly again. With the highest degree of brightness it reaches 610 $\mu\mu$.

(3) Green-blind vision appears to exhibit the same phenomena as the trichromic.

(4) In red-blind vision the maximum moves at first towards the long wave-length; with mean illumination it attains to the wave-length 570 $\mu\mu$; it then remains stationary for higher degrees as far as the observations extend.

The statement (1) was predicted by Hering and was also observed shortly before the publication of these investigations. Nevertheless, it cannot be regarded as a proof of the correctness of Hering's theory for the distribution of brightness if the spectrum in individual cases is unchanged when by certain pathological processes the real sensation of colour is lost, and only the sensation of black-grey-white remains. (*Phil. Mag.* [5], xxxiii. 54.)

A. Chauveau considers that there exist distinct nerve centres for the perception of the fundamental colours of the spectrum, one for the green and probably others for the red and violet. Of these the green centres are those which first regain their activity on awakening, so that objects appear for a moment illuminated by a bright green light. (*Comptes Rendus*, cxv. 908.)

W. de W. Abney in a preliminary note of a part of a paper on Colour Photometry communicated to the Royal Society, describes a method by which colours may be accurately numerically registered. Three rays are selected in the spectrum, one in the red R (between C and the red Li line), one in the green G (between F and b), and one in the violet V (on the H side of and near to G). By varying the luminosities of these three rays and mixing them, the same impression can be given to the eye that any compound colour gives. Also by mixing them in the proper proportion the impression of a standard white can be given to the eye. Thus by subtracting from the luminosities which form the compound colour amounts necessary to make white light, the compound colour may be expressed in terms of two of the three selected rays and a proportion of white light. If the two remaining rays are G and V, or R and G, since the intermediate spectrum colours from G to V, when slightly diluted, are imitated by mixing G and V in proper proportions, and similarly for those between R and G, any combination of G and V, or of R and G, can be further reduced to one spectrum colour and white light. Thus finally the compound colour in question can be reduced to a single spectrum colour plus white light. In the case where this process would leave as the two remaining rays R and V, since there is no part of the spectrum which con-

tains simple colours giving the same sensation as mixtures of V and R, instead of subtracting the constituents of white light from the luminosities of the three selected rays which make up the compound colour, these luminosities are subtracted from a suitable proportion of white light so as to leave only two colours, which will be either R and G, or G and V. Therefore, in this case the compound colour is reduced to white light minus a single spectrum colour (which is, of course, its complementary).

Thus the hue and luminosity of any colour, however compounded, can be registered by reference to white light and a single ray of the spectrum, which is termed the dominant ray, and the practical determination of which is easily made by Abney and Festing's colour-patch apparatus. The determinations by this method of the hues and luminosities of the coloured paper discs used in the Maxwell's colour top experiment, renders the use of these discs far more accurate and definite than if they are simply used as indeterminate colours. For since the sum of the luminosities of any colours is equal to the luminosity of the same colours when integrated, it follows that when using the discs the dominant rays are really mixed and the white light inherent in each can be deducted. (*Proc. Roy. Soc.*, xlix. 227.)

S. P. Thompson, in a paper read before the London Physical Society, showed that, just as white light can be split up into two "complementary" colours, so also any coloured light, not monochromatic, can be split up into pairs of tints, which the author terms "supplementary" colours. These are formed when in any of the usual arrangements for producing complementary colours on the screen a coloured medium is interposed. A great variety of tints can thus be obtained from a single medium, and one of the supplementary patches can always be got of a greyish hue and the other nearly a pure spectrum tint. Prof. Thomson thus verifies Abney's law that any colour can be produced by diluting some spectrum tint with white light. (*Nature*, xlv. 452.)

W. Baily utilises the above-mentioned Abney's law to construct a colour-map. In this map the ordinate of a point, taken along a vertical line on which is marked the succession of spectrum colours, is made to represent the spectrum colour by its wave-length. Abscissæ measured to the right of the vertical line represent amounts of white light to be added to the spectrum colour; those measured to the left the quantity of white light produced by the addition of the spectrum colour to the colour indicated by the point. Three curves are drawn to the left of the spectrum line, the abscissæ of which represent arbitrarily

the proportions of the three primary colours present in the corresponding spectrum. The map is further developed by the author, and an experimental method suggested, by which the proper proportions of the primary colour sensations at the various parts of the spectrum may be determined. (*Phil. Mag.* [5], xxxvii. 496.)

The rainbow.

Mascart, in the *Comptes Rendus*, gives an interesting explanation of the "white rainbow," also called "Ulloa's circle." This is a circular bow, white or only slightly tinted, the radius of which may be as small as 33½°, instead of 40°, as in the ordinary rainbow. The hypothesis, originated by Bravais, which attributes it to the reflections and refractions of light in vesicular water drops appears quite improbable. The diminution of the radius is easily explained by the displacement, in proportion as the diameter of the water droplets diminishes, of the first maximum of the interference fringes which produce the supernumerary bows. The enfeeblement of the colour is due, in part, to the simultaneous existence of droplets of different sizes, the fringes of which overlap; but this explanation is incomplete. Mascart has recently had the opportunity of observing a bow, nearly white, with a slight tinge of red on its outer border, the radius of which was 36½°. Without being able to measure the water droplets, it seemed, nevertheless, that they were sensibly uniform in size. The disappearance of colour pointed, therefore, to the extension of the interference fringes. In this case the relative intensities of the different colours preserve for a sufficient time equal values, and the bow appears sensibly achromatised at least in certain points. This conclusion Mascart has verified by calculation from Airy's formulæ, and he finds that when the diameter of the droplets is 30 microns (*i.e*, thousandths of a millimetre, symbol μ) the achromatism is most perfect. As observation shows that the diameters of the droplets of clouds and mist varies from 6 to 100 microns, circumstances favourable to the production of the white rainbow are very frequent. The enfeeblement of the colours occurs even when the diameters of the droplets differ considerably from those which correspond to the most perfect achromatism, but it persists longer when the diameter diminishes. If regard is had to the apparent diameter of the sun, which enlarges all the fringes, and to the mixture of droplets of slightly different sizes, which makes them overlap, it seems that the rainbow may appear absolutely white, save for a reddish tinge on the outer edge, and without any trace of supernumerary fringes. (*Comptes Rendus*, cxv. 429 and 453.)

Aberration, and the connection between ether and matter.

In the "Year-Book" for 1891 an account was given of the preliminary results of some experiments by **O. J. Lodge** on the effect of moving matter on the ether in its neighbourhood. Dr. Lodge has now given a full account of his experiments in a communication to the Royal Society, in which he discusses generally the question of aberration and the connection between matter and the ether and the motion of the ether near the earth. (*Proc. Roy. Soc.*, li. 98.) He has also treated of the same subject in a Friday evening discourse at the Royal Institution (*Nature*, xlvi. 497), and in a communication to the Physical Society he gave an historical summary of the present state of our knowledge of the connection between ether and matter. (*Nature*, xlvi. 164.)

The question which Dr. Lodge sets himself to consider is whether the earth drags some ether with it, or whether it slips through the ether with perfect freedom; in other words, whether the ether is wholly or partially stagnant near the earth, or whether it is streaming past with the full terrestrial velocity of nineteen miles a second. In discussing this question, the nature of aberration, and of Doppler's effect, and their relations to motions of source, medium or receiver, are fully considered. The result of this discussion is to show that—(1) Source alone moving produces a real and apparent change of colour; a real, but not apparent, error in direction; no lag of phase except that appropriate to altered wave-length; a change of intensity corresponding to different wave-lengths. (2) Medium alone moving, or source and receiver moving together, gives no change of colour; no change of direction; a real lag of phase, but undetectable without control over the medium; a change of intensity corresponding to different distances, but compensated by change of radiating power. (3) Receiver alone moving gives an apparent change of direction; no change of phase, except that appropriate to extra virtual speed of light; change of intensity corresponding to different virtual velocity of light. Thus motion of the medium is incompetent to produce any aberrational or Doppler effect, and hence arises the difficulty of ascertaining whether the general body of the ether is moving relatively to the earth or not. Stellar aberration exists, but it is due to motion of observer and of observer only; and when the observer is stationary with respect to object there is no aberration at all. Hence surveying operations are not affected by the existence of a universal ether drift, and they therefore afford no means of detecting it.

If the ether behaves as a perfectly frictionless inviscid fluid,

so that the earth carries no ether with it at all, then all rays will be straight, and aberration will have its simple and well known value. But in such a case glass and other transparent terrestrial bodies would have the ether streaming through them with an enormous velocity, and differences of refraction of light through them should be produced when the direction of this stream is varied. Experiments in this direction by Arago, Maxwell, Mascart, and others, have failed to yield any but negative results. From this it would seem as if the ether must be stagnant—*i.e.*, at rest relatively to the earth.

The experiments of Fizeau and Michelson on the effect of moving water on the velocity of light show that the light is accelerated or retarded to an extent of approximately half the speed of the water according as its direction coincides with, or is opposed to, that of the motion of the water. These experiments support Fresnel's hypothesis that only the excess of ether which the substance possesses over that of surrounding space moves with the body. On this supposition the effects of altered refraction and ether drift compensate each other, and so the experiments become explained. Glazebrook has shown that it is not necessary to suppose, as Fresnel did, an extra density of the ether in the moving matter. To modern ideas the loading of the ether by the presence of matter is more likely to be correct, and the observed effects of relative motion are regarded as the result of secondary reactions of matter on ether. On this view the ether of space may be wholly unaffected by the motion of matter. Fizeau's experiment, however, raises a difficulty from another point of view; for the velocity of light through a transparent body moving with the earth should be accelerated or retarded according to the direction of the ether stream. This effect has been sought for by interference methods by Babinet, Hoek, Jamin, Mascart, and others, but again with negative results. It would therefore seem as if the ether must be stationary relative to the earth.

To reconcile these experiments, Dr. Lodge supposes the ether to be either stagnant or to have a velocity potential. The velocity potential condition is shown to involve Fresnel's law as a special case, and it is capable of reconciling the experiments made. All of these are consistent with absolute quiescence of the ether near moving bodies, or with relative quiescence near the earth's surface. They may be said perhaps to be inconsistent with any intermediate position. The velocity potential condition being granted, and nothing of the nature of viscosity being admissible, the theory becomes very simple, and the results of all the interference, refraction, and aberration experiments could

be predicted. It can then be inferred that *no first order optical effect due to terrestrial motion can exist in a detectable form.* It is always compensated by something else. Quantities of the second order of magnitude must therefore be attended to—that is, quantities depending on the square of the aberration magnitude a These show that the velocity of light along the ether drift should differ from that across it in the ratio $\sqrt{1 - a^2} : 1$. This has been tested by Michelson, but nothing approaching a quarter of the theoretical effect was observed. This negative result would seem to preclude any relative motion between the earth and ether. On the other hand, Dr. Lodge's experiments on the rotation of steel discs show that the ether is not affected by the motion of contiguous matter to the extent of $\frac{1}{500}$ of the velocity of the matter. In these experiments a parallel beam of light is split into two by a semi-transparent mirror (as in Michelson's experiment), consisting of a piece of glass very thinly silvered, so that it lets half the light through and reflects the other half. The two halves of the split beam are then reflected round and round in opposite directions between the two rapidly-revolving steel discs. After thus travelling 20 or 40 feet, they are allowed to meet and produce interference bands. No real reversible shift of the bands due to the motion of the discs could be found. The motion of the discs does not seem to disturb the ether in the least. Thus the two experiments are at present in conflict. It may be that enormous masses like the earth act on the ether gravitationally, straining it so as to produce the same sort of effect as if they dragged it with them. Dr. Lodge proposes to repeat the experiment with larger revolving masses, and also to try the effect of a strong magnetic field.

Lord Rayleigh, in the pages of *Nature* (xlv. 499), publishes an interesting article on aberration, in which the subject is treated, as in Dr. Lodge's papers noticed above, from a general point of view. On the whole Lord Rayleigh considers Fresnel's hypothesis of a stationary ether to be the more probable, but the question must be considered an open one.

H. A. Lorentz also discusses the subject in a communication to the Academy of Sciences of Amsterdam. He suggests as a possible explanation of Michelson's results that the dimensions of a solid body are not absolutely invariable, but depend on the direction of the body with regard to the motion of the ether through it, and that therefore the changes in length of the metallic arms of Michelson's apparatus, or of the stone basis, may have compensated the difference of time of passage of the light in the two mutually rectangular directions. (*Rev. Gen. des Sc.*, iii. 838.)

ELECTRICITY.

BY H. H. HOFFERT, D.Sc., Assoc. R.S.M.

REFERENCE has already been made above to the important step taken by the British Association Committee in convening an International Conference on Electrical Standards. The result of this conference, when its resolutions are adopted generally, as no doubt they will be, and legalised by the various governments, will be the substitution for the time-honoured B.A. ohm, and the too-hastily adopted "Legal ohm," of a new ohm, the value of which is probably so near the true ohm that, for all practical purposes, the two may be assumed to be equal.

Considerable progress continues to be made in the investigation of the phenomena of the propagation of electro-magnetic waves, so brilliantly inaugurated by Hertz. The researches of the French physicist, Blondlot, in this subject are specially worthy of attention. Hertz's own researches are now accessible in a collected form, and an English translation of his book is about to appear.

Considerable advances have also been made in the study of the passage of electricity through gases at various stages of exhaustion. The brilliant experiments of Tesla, to which reference was made in the "Year-Book" for 1891, have been repeated in this country, and have created a widespread interest. The new field of research, opened by Crookes, in which Tesla is working, promises to be one of great fruitfulness in new discoveries. In particular, it is not too much to expect that the maintenance of electro-magnetic vibrations, sought by Prof. Fitzgerald, may be achieved before long. A fuller account of Tesla's experiments than appeared in the last "Year-Book" will be found below.

Electrical units and standards.

The International conference convened by the Electrical Standards Committee of the British Association had before them the question of defining, in the light of the latest determinations of the values of the ohm, ampère, and volt, the standards of these electrical quantities which should be recommended for international adoption.

With respect to the standard of electrical resistance, the first subject under discussion was the dimensions of a column of mercury which has a resistance of one ohm. Professor Von Helmholtz drew special attention to the difficulty of defining the cross section of

the column in terms of the square millimetre owing to the uncertainty which still exists of the relation between the centimetre and the gramme. He suggested that this difficulty might be overcome by defining the *mass* of the column of given length which should have the required resistance. Mr. Guilleaume expressed his concurrence in Helmholtz's suggestions, and gave the results of recent experiments at the Bureau International des Poids et Mesures on the relation of the gramme and the centimetre. It was therefore resolved to define the mass in such a way that assuming the mass of one cub. cm. of water to be one gramme, the area of cross-section should be 1 sq. millimetre.

In determining the length of the column, discussion of the existing measurements showed that 106·3 cm. might be taken as the length with an accuracy of nearly one part in ten thousand—an accuracy quite sufficient for all practical purposes in the construction of a standard. Except in regard to the manner of defining the cross-section, this leads to a result agreeing with resolution No. 4 of the Board of Trade Committee, which runs thus:—"That the resistance offered to an unvarying electric current by a column of mercury of constant cross-sectional area of one sq. mm., and of a length of 106·3 cm. at the temperature of melting ice, etc., may be adopted as one ohm."

On the question of the best method of practically realising the standard of resistance, the discussion showed that the Board of Trade Committee's recommendation that standards of solid metal having the same resistance as the column of mercury should be constructed, verified, and, if necessary, replaced by comparisons with the British Association units, would lead to difficulty. It was accordingly agreed to omit all reference to the B.A. unit in the resolutions; and as recent experiments had shown that mercury tubes and standard coils of wire made by comparison with them at various places, agreed to about one part in ten thousand, it appears that a standard in solid metal having the same resistance as the specified column could be made with all the accuracy necessary, and be recovered with certainty at any future time. The resolutions finally adopted were as follows:—

(1) "That the resistance of a specified column of mercury be adopted as the practical unit of resistance."

(2) "That 14·4521 grammes of mercury in the form of a column of uniform section 106·3 cm. in length at 0° C. be the specified column of mercury."

(3) "That standards in mercury or solid metal having the same resistance as the specified column be made and deposited as standards of resistance for industrial purposes."

(4) "That such standards be periodically compared with each other, and also that their values be redetermined at intervals in terms of a freshly set up column of mercury."

(The number 14·4521 in resolution (2) is arrived at by multiplying the length 106·3 and nominal area 0·01 sq. cm. of the column by 13·5956, the specific gravity of mercury.)

On the question of the standard current it was agreed that the clause of the Board of Trade report—"*That an unvarying current, which, when passed through a solution of nitrate of silver in water, in accordance with the specification attached to the report, deposits silver at the rate of* 0·001118 *of a gramme per second, may be taken as a current of* 1 *ampère*"—expressed the result of experiment with all the necessary accuracy, and should be accepted.

The Clark cell was adopted as the practical standard of E.M.F.,

Recent values found for the E.M.F. of the cell vary within the narrow limits 1·4338 to 1·4345, the majority being near the number 1·4340. It was agreed that the value 1·434 volts at 15° C. might be taken as the E.M.F. of the cell. (*Electrician*, xxix. 447, 462.)

R. T. Glazebrook and **S. Skinner** describe some recent experiments by Lord Rayleigh's method on the E.M.F. of the Clark cell. Assuming the B.A. unit to be 0·9866 ohm, the results gave the E.M.F. as 1·4342 volt at 15°C.; or 1·4324 volt at 62°F. The temperature variation was found to be 0·000755 per 1° C., a result practically identical with Lord Rayleigh's. The comparison of cells set up at different times by different observers showed good agreement. Cells which when first set up showed differences, settled down gradually to agreement with the standard. Cells set up with ordinary stock mercury were at first much too low, but gradually increased and became normal. The mercurous sulphate appears able to free the mercury from harmful ingredients. The authors discuss the Board of Trade instructions for preparing the cells and point out the reasons for the precautions there advised. (*Proc. Roy. Soc.*, li. 60.)

Kahle, at the British Association meeting, gave a summary of the researches carried out at the Berlin Reichsanstalt on the Clark cell. Rayleigh's H form of cell was used, the + electrode being mercury once distilled, and the – electrode an amalgam containing 10 per cent. of zinc. The latter was poured into the cells as a hot liquid, and solidified on cooling. The paste covering the + electrode was made by grinding mercurous sulphate and mercury with a mixture of crystals and concentrated solution of $ZnSO_4$. No heat was used in making the paste. The mercurous sulphate

was purchased, and was found never to contain impurities of noticeable amount. The solution of zinc sulphate was made basic by boiling it with rods of pure zinc; the dissolved oxide of zinc precipitates on cooling and carries with it the oxides of metals more electronegative than zinc. For oxidising the ferrous sulphate which is always present, a small current was sent through the basic solution between platinum electrodes; the ferrous sulphate was thus converted into insoluble ferric oxide. The H cells thus set up never showed a difference greater than $\frac{1}{10000}$ volt. An investigation of the effect of impurities of the Zn, or $ZnSO_4$, showed that the foreign ingredients in the latter were of very little importance, and that only the presence of free acid alters the E.M.F. in a considerable degree. If the zinc is amalgamated it is better to dissolve it in the mercury, using it then as a solid amalgam. The mean E.M.F. of the H cells was 1·4332 volt at 15°C.; the temperature coefficient 0·000796 + 0·000014. When set up in accordance with Prof. Carhart's directions with $ZnSO_4$ solution saturated at 0°C., the E.M.F. was 1·442 volt at 15°C. Dr. Kahle considers that the H form gives more accuracy, and is easier to set up than the original Clark cell, and is therefore best adapted for standards. For portable cells Dr. Kahle, in conjunction with Dr. Feussner, has devised forms with a porous partition. The + pole is an amalgamated platinum plate, placed with the surrounding paste in a porous vessel of clay. The Zn rod forming the — electrode is protected at the upper part by a glass tube; the lower part is covered with crystals of $ZnSO_4$, a saturated solution of which salt fills the rest of the glass vessel. The E.M.F. of these cells is constant within $\frac{1}{10000}$ volt, but higher by $\frac{3}{10000}$ volt than the H cells. Their disadvantage is the lagging of the E.M.F. change behind the temperature change. Attempts have also been made to construct portable cells without porous partitions by using an amalgamed platinum plate and a solid 10 per cent. zinc amalgam as electrodes. The E.M.F. of such a cell is about $\frac{1}{10000}$ smaller than that of the H cells. (*Electrician*, xxix. 516.)

See also St. Lindeck on the Clark cell in the *Zeits. Instr.* xii. 12.

A large series of tests have been made by **K. Feussner** and **St. Lindeck** at the Berlin Reichsanstalt on the applicability of different metallic alloys to the construction of resistance coils. Alloys containing zinc are condemned on account of gradual crystallisation of the zinc. Alloys of Cu and Ni, such as "patent nickel," are more suitable. They have a constant resistance and small temperature coefficient. "Manganin" (an alloy of Cu, Mn, and Ni), when protected by insulation, surpasses all other known

alloys in its utility for the construction of standards of resistance. Its temperature coefficient is almost nil, and after a preliminary "ageing" it has a very constant resistance. (*Electrician*, xxx. 119.)

A discussion on the nomenclature of electrical units was raised at the British Association on a communication by Prof. Oliver Lodge, in which a number of suggestions were made for rendering some of the practical units more convenient in size, and for naming electro-magnetic units. With respect to these suggestions, it was generally felt that the time had not yet come when a general revision of the units could be undertaken with any prospects of finality. (*Electrician*, xxix. 371, 433, 461.)

Production of electricity by waterfalls.

Ph. Lenard has made an important contribution to the study of the production of atmospheric electricity by the friction of water in waterfalls. It has long been known that waterfalls charge the air in their neighbourhood with negative electricity. In particular Elster and Geitel, in their experiments on the Hohe Sonnblick, found the negative electrification observable at a height of 500 metres over the fall, and they expressed the opinion that the phenomenon is due to the action of the normal earth potential on the dispersing water spray. This conclusion Lenard has been able to prove erroneous. The air is itself electrified by the descending water, and the production of spray is not essential. From numerous experiments on the electrification produced by water falling in drops or jets on to a wetted body, it appears that electricity is generated, the water becoming positively electrified while the air escapes negatively charged. When the jets break into spray the electrification is more apparent. The charging of the water when insulated can be made to increase to sparkling potential, and the air potential of the room can be brought to several hundreds of volts. The nature of the gas is of influence, as also that of the liquid. Slight impurities of the water diminish the effect considerably.

Amongst the multiple phenomena of the motion in a waterfall the only active agents are the concussions amongst the water particles themselves and against the wet rock. The chief place of development of the electricity is, therefore, at the foot of the fall; from there the negative electrification of the air spreads out into the surroundings, whilst the positive electrification of the water goes into the earth. The friction of the water through the air and its scattering into spray are electrically inactive. The friction against the rock and the fall of earth potential are of only secondary consideration. When air bubbles were driven under

water the air electrification was lessened, and the same lessening took place when water-spray was present, which separated itself under the influence of the air electrification, with an electrification of opposite sign. Lenard explains these phenomena by the sudden diminution of the water surface, and the convection of the negatively-charged air away from the foot of the fall. (*Wied. Ann.*, xlvi. 584.)

J. Elster and **H. Geitel** reply to Lenard's criticisms in *Wied. Ann.*, xlvii. 496.

Influence machines.

H. Abraham has made a study of a simple type of influence machine suited as much as possible for theoretical treatment, and has been able by its means to establish the following propositions:—(1) The quantity of electricity yielded by the machine is proportional to the charge of the inductor; (2) the yield is also proportional to the velocity of rotation; and (3) the observed and theoretical values of the yield agree to within one per cent. (*Jour. de Phys.* [3], i. 409.)

J. Gray read a paper at the British Association, in which he describes some graphic methods for the elucidation of the action of Maxwell's machine, by applying reasoning similar to that used in Carnot's cycle in the mechanical theory of heat. The diagram of the working cycle is an energy or work diagram in which the components are the quantity of electricity and the potential of the carrier. This method is applied to investigate the conditions of the theoretical efficiency of influence machines. (*Electrician*, xxix. 428.)

Effects of alternating currents of high potential and frequency.

The very interesting experiments of **Nikola Tesla** on the luminous effects produced in exhausted tubes by currents of very high frequency, some account of which was given in the "Year-Book" for 1891 (p 62), have been exhibited in this country by Mr. Tesla, at an extraordinary general meeting of the Institution of Electrical Engineers at the Royal Institution early in the year. The methods which Tesla adopts for producing the very high frequencies and potentials he uses are two-fold. In one method he sets up vibrations of some hundreds of thousands or millions per second in the secondary of a discharge coil, by disruptively discharging a condenser through the primary. For this purpose a disruptive discharge coil is used, in which the parts are all heavily insulated with gutta-percha and oil. The primary consists of two coils, each of 96 turns, of thick gutta-percha-covered

wire, which can be connected either in series or parallel. The secondary consists similarly, of two coils, of 260 turns each, of thinner wire wound in vulcanite spools. The whole is held suspended within a wooden box filled with oil and covered outside with sheet zinc. The condenser which feeds the primary is itself charged by an induction coil or transformer operated by currents of low frequency. The discharger is of special form, and has either a single or a multiple air-gap. In the former case the arc formed between the knobs is blown out either by a blast of air or by a strong electromagnet, so that the fundamental discharges may occur in quicker succession.

Insulated wires connected to the terminals of the disruptive discharge-coil are rendered strongly luminous, with streams issuing abundantly from the whole surface. On connecting a wire circle 30 cm. in diameter to one terminal, and a small brass sphere to the other, a hollow luminous cone stretches from the sphere to the wire, and one-half of the sphere is illuminated. Between two concentric circles of wire connected one to each terminal the streams form a luminous disc, which may be made to cover an area of a square metre. The higher the frequency the more uniform and glow-like do the streams become, so that it is evident that luminous discharges, such as ordinarily occur in vacuum tubes, can take place at ordinary pressures, or at even greater pressures, if the frequency is sufficiently high. Thus, if the aurora borealis be produced, as some suppose, by sudden cosmic disturbances which set the electrostatic charge of the earth in rapid vibration, it may not be confined to the upper rarefied strata of the air, but may traverse the denser parts in the form of a glow.

A curious form of discharge is observed when all parts of the coil are heavily insulated, with only two small spheres, or, still better, two sharp discs exposed to the air, and the frequency and potential are pushed to their extreme limit. Misty-white streams to which the hand may be approached without sensation spread out from the edges of the discs into space.

The display of sparks on an insulating plate of glass between the terminals may be made to cover a plate a square metre in area. According to the variation of the capacity the discharge may be made uniform, or a fine network of silvery threads, or a mass of loud, brilliant sparks.

By connecting large conducting surfaces to the terminals of the coil an electrostatic alternating field can be produced which acts through the whole extent of a room, lighting up a tube no matter where it is held in space. The incandescence of a button,

filament, or wire in a tube can also be obtained by means of inside and outside condenser-surfaces, which condense the energy of the field on to the small body to be rendered incandescent. Intense phosphorescence is excited in a bulb by merely connecting it to a plate within the field. Prof. Crookes's phosphorescent tubes glow intensely merely by holding them in the hand and connecting the body to the terminal of the coil.

The radiant matter state in a Crookes's tube is generally associated with the free path of molecules with extremely high degrees of exhaustion. But the motion of the molecules in straight lines is due not only to the absence of obstacles, but also to their high velocity, and this velocity increases with the potential. Thus a disruptive discharge-coil, when the potential is pushed very far, excites phosphorescence and projects molecular shadows at comparatively low degrees of exhaustion.

Refractory buttons can also be rendered incandescent by connecting them to the ends of a spiral of aluminium wire, entirely enclosed in a tube, which serves as the secondary to a primary coil outside the tube through which Leyden-jar discharges are passed.

But for the experiments on incandescence in exhausted tubes, Tesla prefers his second method of working, on account of its regular and positive action. In this the currents from his specially-constructed alternator, of a frequency of 10,000 per second, operate a small oil-insulated induction coil containing from 5,000 to 15,000 turns in the secondary. To counteract the effect of the self-induction of the secondary and allow the passage of stronger currents, capacity is added to its terminals, and in the condensers used for this purpose gaseous matter must be carefully kept from the charged surfaces. If Leyden jars are used they must be immersed in oil. For a similar reason capacity is also added to the primary circuit and adjusted so as to annul the effect of self-induction of both primary and alternator.

The refractory body in the tubes—such as a carbon button—was usually placed exactly at the centre of the spherical bulb, and the energy conducted to it by means of a leading wire, which either had an external connection or was attached to an internal condenser surface. The button was supported on a short length of carbon filament, and this filament and the glass tube stem containing the leading-in wire was protected from the molecular bombardment by an aluminium tube, separated from the glass by several layers of thin mica. The refractory body need not be electrically conducting. A perfect non-conductor may be rendered incandescent by placing it over a conducting core. When heated

so as to become conducting, the bombardment continues in the ordinary way; or the non-conductor may be held in a piece of arc-light carbon, against the upper surface of which the bombardment first takes place. When bodies of different kinds are mounted in one bulb, the body most easily evaporated or disintegrated eventually takes most of the bombardment to itself. A similar effect takes place with even a homogeneous electrode, and is the principal cause of its disintegration. To be most durable the refractory button must be a sphere with highly-polished surface, such as is obtained by fusing at extreme degrees of temperature some oxide such as zinconia. Interesting effects are obtained with a ruby drop fused by the incandescence. Of all bodies tried, including carbon buttons of all kinds, diamond and carborundum—an artificial production used as a substitute for diamond dust for polishing—are the most refractory, the latter even better than the former.

A curious feature of alternating currents of very high frequency is that they necessitate for many of the experiments the use of only one wire. To produce the same result as when a return wire is used it is sufficient to bring in contact or near the tube an insulated body of some surface. This surface may be the smaller the higher the frequency and potential used.

Space does not permit of further reference to these most interesting experiments, nor to the author's speculations as to the influence they may have on the production of light in the future and the transmission of intelligence without wires. For these the reader must be referred to the report of the lecture in the *Journal of the Institution of Electrical Engineers*, xxi. 51.

The interest aroused by these experiments has led other experimentalists to devote renewed attention to the study of high frequency and potential discharges. At the conversazione of the Royal Society Dr. J. T. Bottomley exhibited Teslaic discharges in vacuum tubes without electrodes, using only a bichromate battery and a small coil. These tubes were made years ago in the course of some experiments by Lord Kelvin and Dr. Bottomley, and were described in *Nature* of January 6, 1881. Messrs. Pyke and Harris showed an inductor-dynamo, and a large number of vacuum tubes worked at 100,000 volts from an oil insulated transformer. By means of condensers formed of large sheets of glass with tinfoil coatings, vacuum tubes of various sizes could be run in parallel. Mr. Crookes showed many brilliant high-frequency experiments. He has given a simple explanation of the flame-like discharges obtained with high-frequency discharges. It appears that the flame is a true flame, formed by the chemical combination of the

nitrogen and oxygen of the air under the influence of the electric discharge, with production of nitric acid. The flame is an endothermic one: that is, sufficient heat is not developed to maintain the combustion, so that energy has to be continuously supplied to it.

At the Crystal Palace Electrical Exhibition experiments on high pressure discharges were shown by Messrs. Swinburne and Co., by means of their hedgehog transformer with oil insulation, and also by Messrs. Siemens Bros. **A. Siemens**, in a paper read before the Institution of Electrical Engineers, gave the results of experiments on the striking distance in air of alternate current transformer discharges. The experiments were made with an alternator giving 100 alternations per second, and a transformer. The voltage was measured by a Lord Kelvin's electrostatic voltmeter. The electrodes were of various forms, such as two parallel discs, a disc and a hemisphere, a disc and point. They were repolished between the successive discharges. One was kept fixed, and the other moved by a micrometer screw reading to a hundredth of a millimetre. The sparking distance in air decreases to a slight extent when capacity in the secondary circuit comes into play. It is independent of the position of the spark-gap in the circuit, which shows that the voltage is propagated uniformly over the whole length of conductor, even if there is some capacity in parts of the conductor. The results obtained with the hemisphere and disc were as follows:—

Volts	2,000	4,000	6,000	8,000	10,000	12,000	14,000	15,000
Sparking distance in mm.	0·45	1·40	2·30	3·25	4·37	5·65	7·32	9·02

The volts here given are those measured on the voltmeter, but it is undoubtedly the highest ordinate of the wave which causes the spark. Assuming the wave to be a sine wave and increasing the voltages in the proportion of $\sqrt{2} : 1$, the figures should be applicable to constant continuous currents. A comparison can thus be made with Warren de la Rue's values for the sparking distance. The result of the comparison in the case of the disc and hemisphere is as follows:—

Volts	... ...	2,000	4,000	6,000	8,000	10,000
Sparking distance	De la Rue ...	0·36	0·87	1·50	2·10	2·75
	Siemens ...	0·25	0·80	1·45	2·16	2·85

The results are therefore practically almost identical.

The sparking distance between a point and a disc is about 30 per cent. higher than between a hemisphere and disc at high voltages.

Experiments were also made on the striking distance in various insulating materials, or, rather, on the potential difference at which a given thickness of the dielectric breaks down. (*Electrician*, xxviii. 431.)

H. B. and **W. Fox Bourne**, in a demonstration before the Old Students' Association of the City and Guilds of London Central Institution, also gave some numerical results they had obtained on the sparking distance of high potential alternating discharges. Messrs. Swinburne's large oil-insulated hedgehog transformer was used, and the voltage was carried up to 75,000 volts registered on a large electrostatic voltmeter. Their values agree generally with those of Warren de la Rue and Siemens, but show some discrepancies. In these experiments, when the current was turned on, a violet brush discharge appeared at the terminals, which changed when the air broke down to a long arc resembling a blow-pipe flame (the flame of burning nitrogen as shown by Crookes). Slate and asbestos act practically as conductors of the discharge; dry wood is soon set on fire by small sparks which are seen creeping along it. Celluloid sheets $\frac{1}{6}$ inch thick break down, but a sheet of good vulcanite is highly resisting. When a sheet of glass is interposed between two flat terminals a network of violet sparks spreads over its surface and arcs form round its edges from one terminal to the other. Finally, the glass is perforated by the discharge, but no hole can subsequently be detected, as the edges of the hole become white-hot and fuse together again, the molten glass being a conductor. Good rubber insulation of cables becomes heated and breaks down and burns, chiefly due to the heating caused by absorption currents. Condensers of tinfoil and paraffin paper break down for the same cause, and glass condensers become heated and crack. The heating is much less in insulating liquids such as oil. Some curious effects were observed with oil. When one electrode was placed at the bottom of a vessel of oil and the other, a wire, was just over the surface of the oil, the oil was violently repelled below the wire and formed a depression there about $\frac{3}{4}$-inch deep. Superposed layers of castor oil and paraffin oil were placed in a glass vessel, and flat electrodes were placed in them, one in each. The surface of the castor oil was raised into a small hill in the middle. This effect was ascribed to the tendency of the capacity of the system to increase; the specific inductive capacity of the castor oil being greater than that of the paraffin. (*Electrician*, xxviii. 512.)

The great value of oil as an insulator for high-tension alternating currents formed the subject of a paper by **D. E. Hughes**,

before the Institution of Electrical Engineers. Prof. Hughes was the first to suggest the use of oil for insulation. He described experiments on the insulating values of different oils, and pointed out the good qualities of the viscid resin oil, which has an insulation 79 times higher than air. Liquid insulators also have the great advantage of self-restoration after accidental piercing by a discharge. (*Electrician*, xxviii. 489.)

F. J. Smith, in a letter to the *Electrician* (xxviii. 553), describes the way in which resin oil is used in Millard Laboratory, at Oxford, to insulate Leyden jars, fulminating panes, and a battery of cells used to charge a quadrant electrometer.

Elihu Thomson describes some further experiments which he has made on high pressure discharges, and the apparatus he employed. A large induction coil or transformer is supplied, with primary alternating currents at 50 or 100 volts, and a frequency of 125 or 250 alternations per second, and transforms them to 10,000 or 12,000 volts. The secondary coil is connected to a condenser of variable capacity. The transformer will give sparks from ½-inch to 1 inch long with the uprising flame-like arc now so well known. When a blast of air is directed on to the discharge, it changes this to a pale purple flame when no condenser is used, but when a moderate capacity is introduced this becomes a mass of flame filled with fine and thick threads which represent the condenser discharges. With greater capacity the discharge becomes thick and white, and when a forcible air jet is directed on to it, it roars very loudly. A second transformer of peculiar form is placed in the circuit which includes the discharge gap upon which the air-jet plays. The primary of this coil is an open helix of 15 or 20 convolutions of heavily insulated line wire 4 or 5 inches in diameter. This is surrounded by a thick glass cylinder, upon which about 150 turns of fine silk-covered wire have been wound in one layer, with a silk thread between the turns. The coil is immersed and well sunk in a jar of heavy insulating oil, and the terminals on leaving the oil are kept well apart, and are insulated by glass tubes. When sparks of ¼-inch length are passing at the first gap, a torrent of sparks 7 or 8 inches long can be obtained between these terminals. The discharges are of at least 150,000 volts potential, which gives an extraordinarily high voltage per inch of secondary wire. These experiments suggest that lightning discharges, apart from their electrostatic effects, may be the source of most vigorous electro-dynamic induction, and that subsidiary high potential discharges may thus result. (*Electrician*, xxviii. 460.)

P. Janet, commenting on an experiment of Elihu Thomson's, in which an electric incandescent lamp is made to glow when connected to the ends of a short and thick straight rod of copper, through which high frequency alternating currents are being passed, points out that the cause of the current through the lamp is to be found in the mutual induction between the copper rod conductor and the rest of the circuit. By carrying one of the wires to the lamp parallel to, but insulated from, the copper rod between the points at which the branch circuit to the lamp is derived, the lamp no longer glows. The connections of the lamp may be entirely disconnected from the copper rod, and the lamp circuit made into a rectangle with one of its sides parallel and near the rod; the lamp still glows. Finally, if for the sake of symmetry, the rectangle is placed between the parallel going and return wires of the alternating current circuit, the arrangement becomes similar to that used by Blondlot in his researches on the propagation of electro-magnetic waves (see p. 86). The rectangle may be interrupted by a condenser, with the result that, if the experimental conditions are suitable, the lamp glows still more brightly. By placing in the circuit a spiral coil to give self-induction, and by varying the amount of this self-induction, the capacity being given and inferior to a fixed limit, the lamp shows a very marked maximum of brightness when the period of vibration of the secondary circuit is equal to that of the primary circuit, and if the latter is varied, as, for example, by increasing the capacity of a condenser, the discharges of which are being utilised, it is necessary, in order to re-establish equilibrium, to vary the capacity or self-induction of the secondary circuit in the same direction. It seems that for the order of frequence here used, the secondary circuit resumes the true *rôle* of resonator, of which the experiments of Sarasin and De la Rue had deprived it in the case of Hertzian oscillations. It must, therefore, be concluded that the oscillations employed are much less rapidly damped than those of Hertz's exciter. (*Journ. de Phys.* [3], i. 375.)

F. T. Walker developes formulæ for calculating the force and couple on a ring of metal placed above the pole of an alternating electro-magnet. He also investigates the experiment of Elihu Thomson, in which a sheet of copper is held over the pole so as to half cover it, and a hollow copper sphere is placed on the sheet; the electro-magnetic action producing a couple which causes the sphere to spin. He ascribes the spinning to the difference of phase between the currents induced in the copper plate and those of the magnet, and not, as has been stated, to the copper plate acting as a screen and rendering the magnetic field unsymmetrical. If the

plate were a perfect conductor it would act as a perfect screen, but there would be no couple. (*Proc. Roy. Soc.*, l. 255.)

The passage of electricity through gases.

F. V. Lepel describes experiments on the oxidation of nitrogen by electric sparks through air. It is well known that small quantities of nitric acid, nitrous acid, and their ammonium compounds, are formed when sparks of high-tension electricity strike through air containing moisture. The first product of the discharge is nitric oxide, which combines with the oxygen of the air to form nitric peroxide. By combination with water there results from this nitric acid, and nitric oxide is again liberated. The subsequent action of the sparks is now to destroy the products it has built up, so that in a confined space a limit is soon reached at which no further increase in the amount of nitric acid takes place. By a slow motion of the air, and by adjusted conditions of pressure and spark discharge, Lepel has succeeded in increasing the production of nitric acid to 10 per cent. of the air employed, and he suggests that by a suitable use of high-pressure electric discharges sufficient nitric acid may be produced commercially to render us independent of natural nitrates as sources of the acid. (*Wied. Ann.*, xlvi. 319.)

Lord Armstrong describes, in the *Proc. Roy. Soc*, lii. 176, some curious effects obtained from the high tension currents of six induction coils supplied with separate primary currents, but with the secondaries all combined in parallel. When the air gap was reduced so as to convert the spark discharge across it into an apparently continuous arc, the negative side of the gap became intensely heated, so that platinum wire became easily fused. The positive side kept perfectly cool. In the ordinary electric arc the heat is nearly all developed on the positive side. From these and other effects, Lord Armstrong concludes that the sparks must be considered as a dying-out alternating current of prodigious frequency, in which the positive alternations have the ascendency, the excess constituting the available current. A series of plates are given to illustrate the effects of the discharges in producing dust figures round the spark gap and wires. A curious phenomenon was observed when the current was passed from one vessel of pure water to another through a string of cotton strands; the string crawled over the edges of the vessels until it was all transferred to the positive vessel; at the same time water was transferred in the opposite direction. The effect is ascribed to electro-capillary actions.

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O. Lehmann, in a discussion of methods of measuring the fall of

potential in electric discharges in gases, describes an experiment which is very similar to that of Lord Armstrong. The current from 1,060 small secondary cells was passed through a water capillary resistance and allowed to discharge across a spark gap about 1 mm. wide. With much resistance in the circuit the discharge passed in sparks like those of an influence machine; with suitable reduction of resistance the sparks succeed one another more rapidly, then pass in a continuous stream, and finally the negative side (cathode) becomes luminous, while the positive side (anode) remains dark. On connecting large condensers to the electrodes, the discharge ramifies in band discharges and sparks, which pass from the anode round the glowing portion of the cathode to the colder part. By blowing on this discharge it changes suddenly into a brush discharge, the anode now glows and the cathode remains dark, and the sparks pass round the hot part of the anode and terminate at the colder portion. On ceasing to blow the discharge passes back again to the first form, and the cathode again glows. This alternation of the discharge appears to show that the difference of the + and − sides of the discharge depends on causes brought about by the action of the discharge itself. Further reduction of the resistance produces the ordinary electric arc with glowing anode. Lehmann also describes experiments on the effects obtained when vacuum tubes without electrodes are rotated in a constant electrostatic field, or when they are placed in a magnetic field of rapidly varying intensity. (*Wied. Ann.*, xlvii. 426.)

Somewhat similar experiments are also described by **E. C. Rimington** and **Wythe Smith**, and were shown by them at the Physical Society. (*Electrician*, xxx. 154.)

A. Schuster, at the British Association meeting at Edinburgh, described the results of further investigations of the phenomenon of "secondary conduction" of a gas. If an electric current passes through any portion of a partially-exhausted gas contained in a closed vessel, the whole of the gas becomes thrown into a sensitive state, in which it is a conductor in the ordinary sense, and a single cell will send a measurable current through it. If the gas is a hydro-carbon, and the secondary electrodes are of platinum, polarisation occurs just as in the case of the electrolysis of water. The electro motive force of polarisation is in this case 3 or 4 volts. No polarisation, or only traces, can be found in O, H, N, cyanogen, aqueous vapour, ammonia, and other gases experimented on, but phosphuretted hydrogen shows the phenomenon. With electrodes of copper or iron no polarisation is found in hydro-carbons. On the other hand, where aluminium or

magnesium is used, it rises to very high values. Thus Mg electrodes, between which the current from 30 Clark cells was allowed to pass for some time, showed a polarisation of 35 volts. The fact that the E.M.F. depends so much on the nature of the metal tends to show that a metallic carbon compound is formed by the action of the primary current, and that the effects are analogous to those of a secondary cell.

Permanent currents may be obtained by placing electrodes of magnesium and platinum in a gas which has been rendered sensitive. The magnesium is always electro-negative to the platinum. The E.M.F. is different in different gases, being higher, for instance, in O than in H. (*Electrician*, xxix. 429.)

Prof. Schuster also discussed some interesting points connected with the phenomena observed in the electrical discharges in gases, in his Presidential Address to section A of the British Association.

J. J. Thomson has been making further observations on the electric discharge in bulbs without electrodes. He shows that the colour of the discharge through the same gas varies very greatly with the density of the gas and the intensity of the discharge. This was shown by two bulbs containing air; the discharge through one was a bright blue, and through the other an apple-green. It was also shown that a gas at a low pressure could not act as an electro-magnetic screen, though it did so at high pressures. The laws governing the absorption of energy by conductors placed near very rapidly alternating currents were illustrated by experiments, which showed that there was a much greater absorption of energy by small pieces of tin-foil than by large masses of brass or copper. When no electrodes are present the discharge passes through air at a pressure somewhat less than that due to $\frac{1}{250}$ of a mm. of mercury, with greater ease than at either a higher or a lower pressure. Mr. Peace has shown (see below) that when electrodes are used the critical pressure may be as high as that due to 250 mm. of mercury, so that as the spark length is altered the critical pressure may range from 250 mm. to $\frac{1}{250}$ of a mm. J. J. Thomson points out that this involves the possession, by a gas conveying the discharge, of a structure much coarser than any recognised by the kinetic theory of gases, and he suggested a theory of such a structure, and showed that the theory would account for the influence of spark-length and pressure on the potential difference required to produce discharge. (*Proc. Camb. Phil. Soc.*, vii. 314, 330.)

The experiments of **J. B. Peace**, referred to above, were made for the purpose of investigating the relations between the potential

difference, spark-length and pressure, when discharge takes place between two parallel plates in air. In a first series of experiments the discharge was obtained between discs of highly-polished brass, one of which was slightly convex. The current was obtained from a large number of small secondary cells, set up in groups of 500. The pressures ranged from 20 to 300 mm. of mercury. The results of these experiments, when plotted in curves showing the relation between potential difference and pressure, exhibit well-marked minima at relatively high pressures. These minima are as follows:—

Spark-length in inches	0·0004	0·0010	0·0020	0·0040	0·0080
Minimum P.D. in volts	326	330	333	354	370
Pressure, mm. of mercury	240	150	110	55	33

These P.D. curves meet and pass above each other, or, which is the same thing, the curves showing the connection between potential difference and spark-length, also exhibit minima, indicating, therefore, that equality of potential difference existed for two different spark-lengths. To test this at lower pressures, a second series of experiments was made, with two pairs of plates at different distances apart, but with the same air pressure. The plates were arranged in parallel, so that an alternative path was offered to the discharge. The four plates used were plane, and were separated by small thin discs of ebonite, mica, or glass, the thickness of which was taken as the spark-length. Two pumps were used, a water-pump for rapid exhaustion, and a mercury-pump for lower pressures to 2 or 3 mm. The potential difference was measured directly by a cylinder quadrant electometer. The sparks at the two pairs of plates were separately examined until pressures were reached at which the potential difference necessary for discharge became nearly equal, and then the two pairs of plates were simultaneously connected to the cells. The crossing of the P.D. curves was thus directly verified, a slight lowering of the pressure transferring the discharge from the shorter to the longer air-gap. The following table extends the one given above to the lower pressures used in this set of experiments:—

Spark-length in inches ..	0·012	0·021	0·030	0·042	0·082
Minimum P.D. in volts	390	400	428	458	475
Pressure, mm. of mercury	19	12	10	9	7

The curve representing the relation between air-pressure and spark-length for minimum potential difference is a fairly close approximation to a rectangular hyperbola, that is, the product of the pressure and spark-length is approximately constant. (*Proc. Roy. Soc.*, lii. 99.)

M. I. Pupin describes some experiments on the electric discharges in air at moderate degrees of exhaustion, in which he draws attention to the resemblance in many characteristic details which these discharges bear to the character and behaviour of the solar corona. The discharges to which reference is made are those produced in exhausted glass tubes or bulbs without electrodes, by a rapidly alternating electro-motive force applied to condenser surfaces on the outsides of the tubes. The air pressure in the tube varied down to somewhat less than 2 mm. In such tubes the intensity of the luminosity increases with the condenser surfaces of the bulbs, with the frequency of alternations, and with the effective electro-motive force of the charging apparatus.

At low pressures the luminosity is more or less uniformly diffused through the tubes; as the pressure increases the discharge becomes streaked, and at still higher pressures the whole discharge, in its path through the bulbs, divides itself into a number of distinct streamers, the number of which diminishes with the increase of pressure. The streamers rotate more or less uniformly in one direction or the other, and the angular velocity of the rotation seemed to increase considerably with the current of discharge.

Pupin shows that two discharge streamers in the same exhausted vessel exert a repulsive force on one another, which increased continually with the increase of pressure in the vacuum. The cause of this effect is ascribed to a strain in the vacuum produced by the peculiar distribution of the gas pressure resulting from the peculiar distribution of temperature. This view is supported by the fact that the streamers do not mutually repel when in two separated vacua.

Other experiments are described which show the relation between the character of the discharge, the pressure in the vacuum, and the effective E.M.F. which produces the discharge. The behaviour of the discharge at all pressures is considered to support the dissociation theory of J. J. Thomson. A translational motion of the gas is held to be shown along the path of the discharge. Such a motion is rendered evident by the conversion of a rectilinear streamer into a curved one by a blast, or by imparting to the gas a component velocity perpendicular to its original velocity.

Pupin points out the great similarity of the streamers to the solar corona, and illustrates the similarity by the discharges in a large glass bulb, coated equatorially with tin-foil, with a brass sphere at the centre. His paper is accompanied by photographs of the principal effects. (*Amer. Journ. of Science* [3], xliii. 263, 463.)

E. Wiedemann and **H. Ebert**, referring to Crookes's experiment, in which two parallel streams from two negative electrodes in a vacuum tube (cathode rays) exert apparently a repulsive effect on one another, describe an experiment which shows that a repulsion between the cathode rays is not the cause of the phenomenon. In Crookes's experiment there are two similar aluminium cathodes at one end of the vacuum tube and a single anode at the other. In front of the cathodes is a screen of mica with two holes, *a* and *b*, opposite the cathodes. When only one cathode is used the rays cross the tube obliquely from *a* to the anode; when both are used the rays from *a* and *b* are straight and parallel. Wiedemann and Ebert modified the experiment by placing small hinged flaps of mica over the holes, so that either hole can be closed by jerking the tube. They then found that when both cathodes were used the diversion of the rays occurred in exactly the same way, whether one of them was stopped by the flap or not. The diversion is, therefore, not due to the mutual repulsion of the rays, but to the influence on one cathode of the presence of another in its neighbourhood. This accords with the view that the emergence of the cathode rays is influenced by disturbances already pre-existing in the cathode. (*Wied. Ann.*, xlvi. 158.)

E. Goldstein, in discussing the so-called stratification of the light at the cathode, points out that it consists of three parts. In exhausted air there follows after the yellow layer, which is in immediate contact with the cathode, and is usually less than ·1 cm. thick, a feebly-luminous layer, which, with sufficient exhaustion, can be observed up to a thickness of 4 cm. This layer, the "dark space" of Crookes, shines with a faint blue light. The third extends to considerable distances, and forms the greater part of the cathode light. Its colour and luminosity are variable with the degree of exhaustion. These three layers are usually considered as parts of one and the same radiation. Goldstein, in 1886, showed that the so-called "first layer" consists of an independent radiation system of its own, and he now establishes the same independence for the other two layers. This he shows by the use of concave spherical cathodes, which have the property of concentrating the rays of the second layer in a conical convergent bundle, while, on the contrary, the geometrical distribution of the light of the third layer remains unaltered. In this way it can be shown that the rays of the second layer start immediately from the surface of the cathode, and penetrate the whole thickness of the first and third layers up to the outer boundary of the latter. Thus the three layers correspond tc three kinds of luminous emission, which fully interpenetrate one

another, and in the greater part of the cathode light occupy the same space. Each of the three kinds has distinct properties of its own. The production of phosphorescence and of molecular shadows is due to the second kind only, which is alone propagated in straight lines. It is also the only kind which is deflected by a second cathode. The third kind can pass round corners. Goldstein also shows that the secondary cathode light formed at constructions in a vacuum tube also consists of two different kinds of light corresponding to the second and third kinds alone, and he concludes that the positive light also consists of two different kinds of light. (*Sitzber. Konigl. Akad. Wissensch.*, xxxix. 827.)

Lord Kelvin, assuming the velocity of the molecules in Crookes' cathode stream to be 1 km. per sec. (about twice the average velocity in ordinary air), makes calculations which give a rise of temperature of a glass surface on which the stream impinges comparable with that found experimentally, and which show that all the mechanical effects produced by the stream can be accounted for. This very moderate velocity is too small to be detected by optical colour tests. The negative results of such tests is therefore no objection against Crookes' doctrine of the cathode stream. (*Nature*, xlvii. 165.)

H. Hertz has made an examination of the passage of the cathode rays through thin layers of metal. Layers of metal of such thinness that they allow a small part of the incident light to pass through them are transparent to a much larger degree to the cathode rays. This may be shown by coating a portion of one face (the front) of a flat plate of phosphorescent glass with pure gold-leaf, and placing on the gold some flakes of mica. When the plate is placed facing the cathode, which is an aluminium sphere, about 1 cm. in diameter and 20 cm. away, and the exhaustion is carried only so far that the cathode rays fill the discharge tube with a dense blue cone of light, the glass phosphoresces outside the gold-covered portion only. At this stage the phosphorescence is produced principally by the light of the discharge, of which the gold transmits only a very small fraction. When by further exhaustion the proper cathode rays begin to strike the glass, the glass begins to phosphoresce behind the gold, and when the cathode rays have reached their most active development the gold-leaf, when viewed from the back, appears only as a faint veil on the glass plate, noticeable chiefly at the edges and creases. The mica flakes, on the other hand, cast deep black shadows through the gold. The experiment succeeded also with silver and aluminium, with impure alloys of silver and gold containing zinc, tin, and copper, with layers of silver deposited

chemically, and with layers of silver, platinum, and copper deposited by electric distillation in vacuo. Beaten aluminium, such as can be obtained in commerce, appears most suitable; it is quite impermeable to light and very permeable to the cathode rays, and is, moreover, unattacked by the cathode rays, while silver is quickly corroded.

The effect cannot be ascribed to porosity of the metals. The phosphorescence can be excited through three or four layers of gold or aluminium leaf. It happens usually, however, that a second layer weakens the effect more than would be expected. This is probably due to the first layer acting as a mirror and reflecting the phosphorescent light back into the glass, so that if the leaf transmitted, say, $\frac{1}{3}$ of the incident rays the illumination would be diminished only to $\frac{2}{3}$, while if another layer is added it would be diminished to $\frac{1}{3}$ of $\frac{2}{3}$ or $\frac{2}{9}$, and more layers would speedily cause the phosphorescence to vanish. According to this view, it would appear that a layer which transmitted more than half the rays should, by its reflective action, cause greater phosphorescence underneath it than that on the uncovered part of the glass, and Hertz believes he has observed this effect with chemically-precipitated layers. That the effect is not due to pores is further shown by the fact that the rays passing through the leaf are diffusely scattered, like rays of light passing through a turbid medium. (*Wied. Ann.*, xlv. 28.)

E. Warburg has undertaken an experimental investigation of the electric force at the electrodes in a vacuum tube, and its absolute measurement by electrostatic methods. The experiment was arranged so that the discharge passed between two plane horizontal opposing electrodes, and the attraction which one of the electrodes, usually the cathode, thereby experienced was measured by its apparent increase of weight, the electrode being attached for that purpose to one arm of a specially-constructed balance. The attraction being thus determined, the electric force and the surface density on the cathode surface can be calculated. It was found that the attraction was proportional to the current density. With bright platinum or aluminium electrodes it has the following values in milligrammes per ampère:—

In dry N., from 0·5 to 0·2 mm. pressure.	1300 — 2400
Slightly moist N. ,, ,, ,, ,,	500 — 800
H. ,, 1 ,, 3 ,, ,,	200 — 350

As pointed out by Schuster, there is an excess of free + electricity in the negative glow light, the amount of which is opposite and equal to the − charge on the cathode. Like this

charge, it is proportional to the square root of the current density, and has been found to amount (with bright cathodes of platinum or aluminium in nitrogen or hydrogen) to 10^{-10} coulombs per sq. cm. for a current of 1 milliampère per sq. cm.

The surface of the anode is much more feebly attracted than the cathode, and is therefore more feebly charged. If, then, two infinitely large parallel electrode surfaces are placed opposite one another they are equally charged only so long as the electricity is in equilibrium. When the glow discharge passes between them the charge on the anode is feebler than that on the cathode by the excess of free + electricity which is present in the gas through which the discharge passes.

At the normal current density at which the negative glow light can spread freely over the cathode, the electric force at the cathode decreases with decrease of pressure of the gas, and is less for hydrogen than for nitrogen. Thus the excess of free + electricity in the gas also decreases with decrease of pressure under the same conditions. The material electric charge which the gas receives in the glow discharge produces an increase of hydrostatic pressure, and therefore, under ordinary circumstances, with electrodes of limited size, produces eddy currents which flow from the anode to the cathode. These currents may account for the frequently observed transfer of matter in the direction of the positive current. (*Wied. Ann.*, xlv. 1.)

K. Angström has made a series of determinations by a bolometric method of the radiation of gases under the action of the electric current. The light from the + electrode was examined, that from the − electrode being too feeble and variable.

For a given pressure the radiation of + light is proportional to the intensity of the principal current. The intensity of the total radiation scarcely varies between the limits of pressure 0·1 to 1·5 mm., but it increases a little at higher pressures. For the same gas under the same pressure the composition of the radiation is constant, and does not depend on the intensity of the electric current. When the density of the gas changes, the composition of the radiation changes also, in so far that the ratio of the intensity of the radiation of the shorter wave-lengths to that of the total radiation decreases with increase of pressure. The ratio of the luminous to the total radiation rises to considerable values for very low pressures, values far greater than that of ordinary luminous sources. At pressures of 5 to 10 mm. the ratio is rather small. The intensity of the total radiation varies greatly in different gases, and does not appear to be related simply to the molecular weight or to the potential difference in the layer of

radiating gas, or to depend essentially on the absorption of the gas at ordinary pressures and temperatures either as regards its intensity or composition.

Angström ventures the following explanation :—In the case of very low pressures the radiation is principally from the active molecules transporting the electricity. The number of these molecules is proportional to the intensity of the current, and varies but little with the pressure as long as the discharge retains its character. The radiation is of the kind termed by Wiedemann "luminescence," in that its composition does not correspond with the temperature of the gas; it may be of extreme intensity in the group of short wave-lengths. When the pressure increases, and with it the number of inactive molecules, the irregular radiation of the active molecules may be more easily communicated to the latter, so that the number of radiating molecules increases, and consequently also the radiation of the gas; but it changes in character in this sense, that the radiation of the groups of shorter wave-lengths relatively decreases. (*Phil. Mag.* [5], xxxiii. 387.)

E. Branly describes a curious case of unipolar conduction of a gas, observed when the electrodes in the gas are in the one case a metal raised to a red heat, and in the other a metal at the ordinary temperature. The conductivity of the gas is much stronger when the cold metal is negative. (*Comptes Rendus*, cxiv. 831.)

Action of light on the electric discharge.

The discharge of electricity by rays of light is generally considered as limited to negative electrification. **E. Branly** has shown in 1890 that the discharge of a positively electrified metal surface exposed to the radiation of very refrangible rays may become nearly equal to that of a negatively charged surface. For this purpose Branly used the light of the sparks of a Leyden jar attached to an induction coil with a rapid interruptor. He has recently (*C. R.*, cxiv. 68) experimented with the radiation of the electric arc on discs of metal (Cu, Al, Mg) of about 7 cm. diameter. With an arc of 4 mm. the ratio of the times taken by a + charge and a — charge to fall from 300 to 270 volts was $\frac{1}{20}$; with a smaller arc $\frac{1}{30}$; and with an arc of 2·5 mm. about $\frac{1}{40}$. Thus the positive loss becomes slower as the voltaic arc decreases, which is analogous to the results obtained with the sparks, where an increase of distance, or interposition of a plate of quartz, lessened the positive rate of loss much more than the negative. Colourless fluorspar and rock-salt are more transparent to the active rays than quartz. Neither mica nor glass is completely opaque to the active rays.

J. Elster and **H. Geitel** have continued their investigations of

the behaviour of cathodes of alkali metals in Geissler tubes when exposed to luminous radiation. They now show that the resistance of the Geissler's tube to the luminous discharge of an inductorium is lessened by exposing the pure alkali metal forming the cathode to luminous radiation. The phenomenon is especially evident with low pressures of gas, from 0·1 to 0·01 mm. of mercury. By placing small tubes containing the highly sensitive cathode surfaces in various positions in a magnetic field, it is seen that the action of the field depends on the angle between the lines of force and the direction of the electrical current. As in other forms of glow discharge, the current meets with greatest resistance when its direction is perpendicular to the lines of magnetic force. Elster and Geitel also show that the changes of resistance of the vacuum tubes produced by illumination of the cathode by a suitable source of light can be measured by a galvanometer. For this purpose the sensitiveness of the tube was increased by the use of very highly purified potassium, heated in a stream of pure dry hydrogen, by adjusting the pressure in the tube to that value, 0·33 mm. of mercury, at which the exhausted hydrogen has its greatest conductivity, and by the use of a larger cathode surface of potassium in a bulb 3 cm. in radius. On connecting a sensitive Rosenthal galvanometer of 318 ohms resistance to the electrodes, a deviation of the needle was produced even without the use of any cell, when the sensitive surface was illuminated. The potential difference arising from the illumination was not measurable by an electrometer. The increase of resistance in a magnetic field was also easily demonstrable with the galvanometer. (*Wied. Ann.*, xlvi. 281.)

The voltaic arc.

S. P. Thompson discussed the physics of the voltaic arc in a communication to the British Association at Edinburgh. Measurements by Prof. Thompson previously have shown that the seat of the so-called back E.M.F. of the arc is at the crater, and he was led to the supposition that its origin was to be found in the volatilisation of carbon at that surface. Recently, however, Crookes has shown that the flaming discharges produced by alternating currents of very high frequency are endothermic flames of nitrogen (*see* p. 70). Prof. Thompson has therefore made experiments to test whether the combination of nitrogen and oxygen at the high temperature of the arc had anything to do with the voltage of the arc. The arc was surrounded by a tube into which various gases, oxygen, hydrogen, nitrogen, carbonic anhydride, etc., were passed. No difference amounting to one volt could be found. Thus the back

E.M.F., or whatever it may be, is independent of the surrounding atmosphere. (*Electrician*, xxix. 460.)

F. Stenger by employing a modification of a method previously used by Lecher, confirms his conclusion that there is no counter electromotive force in an electric arc, and proves that if such an E.M.F. were existent, Lecher's arrangement is sufficiently sensitive to detect it. (*Wied. Ann.*, xlv. 33.)

Electromagnetic radiation.

A large number of communications relating to this subject have been made to various physical societies and journals during the year. Prof. Hertz has republished his collected papers in book form, and has added an historical account of his work, and a forgotten paper of Von Bezold's written more than 20 years ago. In this paper Von Bezold seems to have anticipated some of the more recent results of Hertz and Lodge in a striking manner.

The most important of the additions to our knowledge of electro-magnetic radiation are, undoubtedly, those of **R. Blondlot**.

In the *Journal de Physique* ([2], x. 549) Blondlot commences a description of his researches by indicating the train of ideas which led him to the methods he has employed in studying the velocity of propagation of electric waves. Since, as shown by Sarasin and De la Rive, it is the resonator which determines the wave-length which is observed (see also p. 94), the equation $\lambda = VT$ should be satisfied by substituting for λ and T the values of the wave-length and period of the resonator, and for V the velocity of propagation of the waves. An exactly analogous case holds in sound. Savart showed that by exploring with the aid of a resonator in the neighbourhood of a plane reflecting surface the sonorous field of a complex sound, or noise, a series of nodes are found, the interval between which is half the wave-length of the proper sound of the resonator used, so that the equation $\lambda = VT$ is satisfied by substituting for V the velocity of sound, for T the period of the resonator, and for λ twice the length of the internode found in exploring the field with the resonator. Therefore in the case of the *electric noise*, produced by a Hertz oscillator, it is sufficient in order to find the velocity of propagation of the electric waves to determine the period T, and wave-length λ, of the resonator employed.

The determination of T offers difficulties. These difficulties Blondlot has overcome by using a special form of resonator, made as follows :—A condenser is made by placing two circular plates 12 cm. diameter a fraction of a millimetre apart. The plates are joined by a rectangular circuit formed of a copper wire 0·184 cm.

diameter. The sides of the rectangle are 10 and 20 cm. long. The total length of the circuit 59 cm., being very short compared with the wave-length λ, it follows that the oscillatory current has sensibly the same intensity throughout the circuit. In consequence it is possible to apply Lord Kelvin's formula, and since Lippmann has shown that in the case of very rapid oscillations the resistance may be neglected, the formula becomes $T=2\pi\sqrt{(CL)}$, where C is the capacity of the condenser and L the self-induction of the circuit. C was measured by Maxwell's method, and L calculated from the geometry of the circuit, thus T was found, and it only remained to measure λ. As Sarasin and De la Rive have experimentally established that the velocity of propagation of waves is the same in air and in metallic wires, Blondlot employs the latter mode of propagation. Two copper wires about 25 cm. long were stretched parallel to each other at a distance apart about 1 cm. greater than the width of the rectangle of the resonator. A movable bridge of copper wire puts the wires in communication at any distance from the ends. Along these wires the electric waves are sent by the aid of the arrangement used by Hertz and by Sarasin and De la Rive. The resonator is placed so that the two long sides of the rectangle are in the same plane with, and parallel to, the long wires. Each side is about $\frac{1}{2}$ a centimetre from its respective wire. It is furnished with a small micrometer spark-gap, consisting of a ball soldered to one of the condenser plates, and a point fixed to the other. The interval can be regulated at will by the aid of a screw. A wire bridge is moved along the wires, and its positions found at which the sparks are caused to disappear at the resonator. From these positions the half wave-length can be determined. Besides the resonator given above, Blondlot has used three others of different dimensions. With each an unlimited number of observations can be made by varying the distance of the condenser plates. The measurements of the velocity of propagation thus made were very concordant, and led to the conclusion that "*the electrical waves have a definite velocity of propagation, which is independent of the wave-length, and that this velocity is approximately* 297,600 *kilometres per second.*" The difference between this number and that obtained by various observers for the ratio of the electromagnetic and electrostatic units of electricity is not greater than the differences between the latter quantities themselves. The number is also equal, to the same degree of approximation, to the velocity of light. Maxwell's predictions are therefore verified, and at the same time the application of the formula $T=2\pi\sqrt{(CL)}$ to the resonators is justified *a posteriori*.

In the course of the experiments Blondlot proved that the

diameter of the parallel wires is without influence on the positions of the nodes; also that the total length of the wires is indifferent, provided they are sufficiently long for the resonator to be placed not too close to the oscillator. The method rests solely on experimental data, and is independent of any theory of resonance, nevertheless it is interesting to note that it is confirmed by this theory, as established by Bjerknes and Poincaré. (*Journal de Physique* [2], x. 549.)

In addition to inventing a new form of resonator, Blondlot has also devised a new method of transmitting the electrical waves along the metallic wires. The primary circuit or exciter consists of a condenser formed of two circular armatures, 12 cm. diameter and separated by at most 1 cm. To these armatures are soldered two copper wires, 3 mm. diameter, terminated by knobs, and curved so that each of them forms a little less than the half of a circle 2 metres in diameter. The knobs are connected by two wires to the poles of the induction coil. When the coil is working the condenser becomes charged, then discharges itself by a spark between the knobs; this discharge is oscillatory. The secondary circuit is formed of a copper wire curved to form a circle 1 cm. smaller in diameter than that of the primary circuit. This wire is covered with a caoutchouc tube and placed close against the primary circle. Its ends terminate at two points on either side of the diameter through the condenser and the two knobs. The oscillations in the primary circuit produce around it a periodic field of electro-magnetic force of great intensity, and sparks as much as 11 mm. long can be obtained between the ends of the secondary circle. The circular form given to the exciter is not essential. Other forms, especially rectangular, are equally good.

To transmit the undulations, the ends of the secondary circle are soldered to two copper wires stretched parallel to one another. Between these is placed the resonator employed in the experiments on the velocity of propagation of the electromagnetic waves, and described above. The phenomena, when thus produced, are very intense. The primary spark is always oscillatory without the necessity of repolishing the knobs. It is easy to change the period by altering the distance between the condenser armatures. Finally, electrostatic effects are non-existent.

To augment the action of the resonator, Blondlot places the parallel copper wires about 2 cm. apart, and at the place where the rectangular resonator is to be situated bends them out to form a rectangle a little larger than that of the resonator. The resonator is then placed within this rectangle, and as the

inductive action takes place on all four sides, and at a very small distance (0·5 cm.), the effects are very intense. As in this case it is impossible to move the resonator along the wires, Blondlot employs to determine the wave-lengths the method of movable bridges. (*Comptes Rendus*, cxiv. 283.)

R. Blondlot and **Dufour** have further shown that when a dissymetry is introduced into the two parallel wires along which the oscillations are propagated, by cutting one of the wires near its junction with the circle and joining the cut ends by a loop of copper wire of variable length, the length of the loop has no influence on the position of the bridge which annuls the spark in the resonator, and that, therefore, the length of the wave measured by the aid of the resonator is independent of the dissymetry of the two wires which transmit the electro-magnetic waves. This result extends the application of Sarasin and De la Rive's principle, that the wave-length is determined by the resonator only, to the case of dissymetry of the transmitting wires, and is similarly explained by Bjerknes' theory of resonance, viz.: that the resonator will be set in vigorous oscillation when the distance from the resonator to the bridge and back is an even multiple of the half wave-length which corresponds to the natural oscillations of the resonator itself, and is therefore the same for all waves which are propagated along the wires, whatever their phases and directions of propagation. The length of the loop, however, influences the intensity of the effects at the resonator according as the different waves which arrive at it are more or less concordant. Thus the resonance should become very vigorous when the length of the loop is an even multiple of the half wave-length, and very feeble when the length is an odd multiple of the half wave-length. In practice the lengths should be a little less than these values on account of the shifting of the position of maximum effect of the undulations caused by the relatively greater enfeeblement of the retarded waves. (*Comptes Rendus*, cxiv. 347.)

In another communication **Blondlot** shows that theoretical reasons founded on considerations of homogeneity of the medium lead to the conclusion that the length of the waves which a given oscillator is capable of emitting should be the same whatever the insulating medium in which the experiment takes place. This conclusion he has verified by experiments on liquid dielectrics. The waves produced in the manner described above were transmitted along two parallel wires of tinned copper, 8 cm. apart. A gilt copper resonator was arranged between the two wires, the part forming the condenser being placed horizontal and within a

glass vessel. The portion of the transmitting wires on the far side of the resonator was contained in a wooden trough 4 metres long. The glass vessel and trough being empty, the position of the movable bridge was determined, at which no sparking occurred; the distance of the bridge from the resonator was then a quarter of the wave-length proper to the resonator. The glass vessel was then filled with the liquid chosen (turpentine, or castor oil), and the wave-length became much greater. The trough was then filled with the same liquid, and the position of the bridge for no sparking was found to be exactly the same as when both the glass vessel and trough contained only air. This is analogous to the acoustical experiment in which an organ-pipe emits waves the length of which depends only on the length of the pipe, and not on the nature of the atmosphere in which it is made to vibrate. From this law Blondlot draws an important conclusion, which Potier has also noticed. On multiplying both sides of the equation $T = 2\pi\sqrt{LC}$ by V, the equation becomes, since $VT = \lambda$, $\lambda = 2\pi\sqrt{L}\ V\sqrt{C}$, and as λ and L are independent of the dielectric medium, the product $V\sqrt{C}$ must be so likewise. In passing from air to another medium C becomes K times greater, while V must be multiplied by the reciprocal of the refractive index $1/\mu$ of the new medium. Thus $K \times 1/\mu^2 = 1$, or $K = \mu^2$, which is the relation arrived at theoretically by Maxwell. Blondlot has therefore verified this relation for the two liquids he used, and his experiments confirm those of Arons and Rubens, quoted in the "Year-Book" for 1891 (p. 76). In the case of castor oil, the value they give for $\sqrt{K}$ is 2·18, while the index of refraction μ_∞ for infinitely long waves, calculated by Cauchy's formula, is 1·467. It is not Maxwell's relation which is here at fault, but the method of calculating μ_∞ (see also p. 32). In Blondlot's experiments the condition is fulfilled that K and μ relate to waves of the same length, and the method has the further advantage that it is independent of all measurements, and involves only a determination of the equality of two lengths.

Blondlot finally points out that the reasoning founded on the consideration of homogeneity supposes that the dielectric properties of the medium are expressible by a single constant. If several co-efficients were necessary, the wave-length would no longer be independent of the medium, and Maxwell's relation might fail. Experiment alone can decide this point. (*Comptes Rendus*, cxv. 225; also *Electrician*, xxix. 357.)

G. A. Fitzgerald, at a meeting of the Physical Society of London, made some suggestions for the maintenance or driving of

electromagnetic vibrations by electromagnetic or electrostatic engines. Comparing such vibrations with those of sound, the discharges of a Leyden jar or condenser are analogous to the transient sound produced by suddenly uncorking a bottle; the effect which it is desired to obtain is analogous to that of blowing continuously over across the top of the bottle; in other words, some form of electrical organ-pipe or whistle is required. Various suggested methods towards attaining this object were discussed.

The first device suggested was to use a discharging circuit, part of which was divided into two branches with a secondary circuit between them tuned to respond to the primary vibrations. If spark-gaps were put between the ends of the branches and the main wire, the magnetic effect of the secondary should cause the spark to choose the two paths alternately, like the air-current at the lip of an organ pipe.

Another device was based on the use of an ironless dynamo of sufficiently rapid rotation, made to send a current through itself. Electrostatic machines were considered, however, more promising, and from the fact that alternating currents could be made to drive electrostatic multipliers Fitzgerald considered that the latter might be made to drive alternating currents. A modified form of electrostatic multiplier was described, which it was thought might possibly afford a feasible solution of the problem. In this machine the collectors were supposed joined to the ends of the vibrating circuit, and would therefore become alternately + and —. Inductors and brushes were to be arranged so that an insulating cylinder turning between them might have a sufficiently large number of + and — charges distributed alternately round its surface, and these charges were to be collected at the proper instants, so as to sustain the vibrations. (*Nature*, xlv. 358.)

In the discussion which followed the reading of this paper, allusion was made to a device of **Trouton** (*Electrician*, xxviii. 302), which consists of passing an alternating current through the field magnets of a dynamo instead of the ordinary continuous current. The current derived from the armature would be of double the frequency, so that the limit of frequency attainable with a single machine could be doubled. This process, however, does not admit of continuous doubling, the successive effects of the addition of other machines only producing an arithmetical and not a geometrical rate of increase, so that to increase the period a thousandfold a thousand machines would be required.

A device for maintaining electromagnetic vibrations based on the property of bismuth, of increasing its resistance in a magnetic field, has been suggested by **T. A. Garrett** (*Electrician*, xxviii. 333).

V. Bjerknes has continued his investigations on the dampening of electrical vibrations in metallic wires, and has attempted to determine whether the properties of the metals have any influence on the propagation of the waves. For this purpose he employed resonator circles of six different metals, of the same diameter and length, viz.—copper, brass, German-silver, platinum, nickel, and iron. The secondary sparks obtained in a Hertz resonator measure the greatest difference of potential between the ends of the spark-gap which arises during the oscillations. According to Hertz's measurements, which were based on observations of the sparking, the influence of the nature of the metals was not felt, but when in Bjerknes' measurements the ends of the spark-gap were connected to an electrometer, which measured the collective effect of several oscillations, the different metals showed very marked differences of behaviour. If the observations are plotted on a diagram, with specific resistances as abscissæ and electrometer deflections as ordinates, the non-magnetic elements are found to be on an even curve, while nickel and iron fall below the curve in proportion to their magnetism. Bjerknes, therefore, states the proposition that "the power of metals to damp the electric oscillations increases with their specific resistance and magnetism." It results from these experiments that the magnetisation of iron follows the oscillations, and that therefore it is possible to reverse the magnetisation of nickel or iron some hundred million times in a second. To ascertain in how far the effects are confined to the surfaces of the wires, Bjerknes covered an iron wire with thicker and thicker electrolytic layers of copper. The wire acted as a pure copper wire when the layer was 0·01 mm. thick. When a copper wire was covered with electrolytic layers of iron, even a layer ·0002 mm. thick had an appreciable effect, and the wire behaved as a solid iron wire when the layer was 0·003 mm. thick. Bjerknes concludes, therefore, that the currents penetrate less deeply into the magnetic metals than into the nonmagnetic metals. (*Wied. Ann.*, xlvii. 69; *Comptes Rendus*, cxv. 725; and *Electrician*, xxx. 69.)

A. Perot verifies Bjerknes' formula for the damping of electrical oscillations in a wire, and supports Bjerknes' and Poincaré's explanation of multiple resonance. (*Comptes Rendus*, cxiv. 165; also *Electrician*, xxviii. 453.)

A. Toepler has succeeded in obtaining very powerful radiation of electrical waves of small wave-lengths (up to 700 million oscillations per second) by means of cylindrical oscillators, 4 to 15 cm. in diameter, connected to a Toepler influence machine with 20 discs, each of 30 cm. radius. The machine was connected

to the oscillator by badly conducting liquid threads, formed by a solution of copper sulphate in capillary tubes. The two halves of the oscillator were in line with one another, and were separated by a spark-gap 7 or 8 mm. wide. The resonators were also of simple straight form, and of a length such that each of the halves was in resonance with the fundamental vibrations of the oscillator. An extremely rapid succession of about 300 sparks per second passed in the oscillator gap, which produced such intense oscillations that an apparently continuous diffuse light, visible even in clear daylight, was produced in the resonator spark-gap. With small oscillators, 14 cm. long, the secondary sparks could easily be obtained at the greatest available distance, 8 metres, without any reflectors, and Toepler considers that under favourable circumstances they could be observed at distances of 50 or 60 metres.

The primary sparks are very sensitive to currents of air, which rapidly extinguish the secondary sparks. Even breathing on the cold surfaces of the primary spark-gap sufficed to render the sparks inactive in producing resonance. Sparks, however, which were not observably influenced by disturbing causes were obtained by connecting the oscillator to a condenser, by the discharge of which through the spark-gap more powerful sparks were obtained in which the rapid oscillations of the oscillator were superposed on the slower oscillations of the condenser. The terminals of the influence machine were connected to the collector-plates of a small double condenser, consisting of two pairs of circular metal plates, separated by a thin sheet of glass coated with paraffin. The collector-plates were connected also to an adjustable discharge-gap. The two plates of the condenser opposite to the collector-plates were connected by thick wire or brass tube conductors to the oscillator, close to the spark-gap. The spark-gap between the collector-plates was made much greater than that of the oscillator. When the machine is worked weak sparks pass the oscillator spark-gap, until the condenser is fully charged, when strongly luminous sparks pass simultaneously at both gaps. The weak sparks are not observably oscillatory; the strong sparks, which, when the machine is at normal speed of revolution, follow one another about 100 times a second, are markedly so. Even with a wide resonator spark-gap (0·5 mm.), the sparks at once appear, and then can be detected at a distance of 8 metres. Toepler shows that it is the rapid oscillations proper to the oscillator itself which are active in producing the resonance.

With this arrangement Toepler has obtained the effects of

resonance within the whole of the space available, both with the smallest influence machine in his possession and with an ordinary Winter's machine. With the 20-disc machine much more powerful effects could have been obtained by the use of larger capacities. The effects even with a small machine were as powerful as are obtained ordinarily with a very large 60-plate machine or a high tension Ruhmkorff coil.

A remarkable property of the influence machine sparks is that the production of oscillations depends upon the speed of rotation of the machine. With the 20-disc machine the speed was about 20 rotations per second. By reducing the speed so that the sparks correspond to that of an ordinary Holtz machine, they were no longer oscillatory, although to the eye unaltered. Sparks starting from a surface of water are oscillationless; probably lightning discharges are not oscillatory for a similar reason. Strong development of sound and light cannot be regarded as indicating the presence of oscillations. The active sparks were remarkably weak in luminosity and reddish-blue in colour. (*Wied. Ann.*, xlvi. 306, 464, 612.)

E. Sarasin and **L. de la Rive** have found that more powerful effects of resonance are obtained when the primary sparks in a Hertz oscillator are made to pass in an insulating liquid. By enclosing the spark-gap in a cylindrical glass bottle containing olive-oil, sparks up to 1 cm. could be obtained in the oil. The effect of this device on the resonator was most marked. Close to the oscillator the spark became a positive blaze, and at 10 metres distance in the case of large resonators—0·75 to 1 metre—it was still very bright and visible from afar. Experiments on the interference effects produced by a plane metallic reflector showed that, as when the discharge takes place in air, they gave the wave-length proper to the resonator employed. When a sufficiently large quantity of oil is used there is no perceptible heating, and the impairing of the liquid by carbonisation does not affect the intensity even after twenty minutes' working. This fact, when compared with the rapid diminution of effect in air which has to be remedied by frequent cleaning of the terminals, is a decided advantage. Essence of turpentine and petroleum were also tried, but oil was found the safest and most advantageous. (*Comptes Rendus*, cxv. 439; *Electrician*, xxix. 578.)

Sarasin and De la Rive have used this new arrangement in repeating their previous experiments on the reflection of electric waves with a very large mirror, 8 metres high and 16 m. broad. The question of the equality of the rate of propagation in air and appears to be definitely settled by the use of the large

mirror, and the conclusions arrived at by Sarasin and De la Rive in previous researches are fully confirmed for large wave-lengths, viz. :—(1) *The secondary resonator has a fixed wave-length, whatever may be the size of the oscillator, the strength of the oscillations alone varying.* (2) *One quarter of the wave-length of a circular resonator is very approximately equal to twice its diameter.* (3) *In the case of normal reflection the first node is exactly at the mirror.* (4) *The rate of propagation of electric waves is the same in air as along conducting wires.* (*Comptes Rendus*, cxv. 1277; *Electrician*, xxx. 270.)

I. **Klemencic** describes a method of determining electromagnetic radiation, by bringing a thermo-element near a fine platinum wire heated by the electrical vibrations in the resonator, and measuring the rise of temperature of the junction. Two series of experiments were made. In the first the resonator consisted of two brass plates, 30 cm. by 5 cm., united by a thin platinum wire 2 cm. long. In this case there was a rate of production of heat of 0·000155 calorie per second. In the second the resonator was a single platinum wire 26·3 cm. long, exposed to the radiation. The heat development in this case was 0·000088 calorie per second. In both cases Hertz's reflectors were used, with a distance of 1·44 metres between the focal lines. The primary wave-length was 66 cm. The second result agrees closely with that of Boys, Briscoe, and Watson (*see* "Year-Book" for 1891, p. 67), since when reduced to 1 cm. of wire both give ·0000033 calorie per second. Owing, however, to the great difference in the two methods, this close agreement is only accidental. (*Phil. Mag.* [5], xxxiii. 396.)

L. **Arons** finds that by enclosing the two wires of a Lecher's arrangement for propagating electric waves in a long glass tube exhausted of air the oscillations can be rendered visible. The tube used was 250 cm. long and 6 cm. in diameter. The two parallel wires passing through it were of aluminium, 2 mm. diameter, and were placed 3 cm. apart. At the ends of the tubes they passed through corks rendered air-tight by sealing-wax. The fixed bridge connected the wires near the far end of the tube. The tube was exhausted to a vacuum of 10 to 20 mm. A cross-bridge connected the wires between the tube and oscillator. When this bridge was moved to a suitable position, 1, 2, 3, 4, and even 5 ventral segments could be obtained in the tube. The wires remained dark at the nodes, but at the ventral segments they glowed with a bluish-white light. The most favourable pressures to use are not below those obtainable with a good water-pump. (*Wied. Ann.*, xlv. 553.)

L. Zehnder describes a method of rendering the oscillations in a resonator visible by means of a vacuum tube containing two electrodes connected to a battery of small accumulators (600 Planté cells) with a potential difference such that the discharge is just unable to pass. Two other electrodes with a small spark-gap are arranged close to the cathode, perpendicularly to the line joining it to the anode. When the Hertzian sparks pass between the latter electrodes the resistance to the passage of the current from the accumulators is diminished sufficiently for the discharge to pass, and the tube lights up. The experiment also succeeds, but not so well, with an induction coil in place of the secondary cells, or by bringing the end of a wire from one electrode near to the primary circuit of the oscillator, and connecting the other electrode to earth. (*Wied. Ann.*, xlvii. 77.)

W. Lucas and **T. A. Garrett** render the secondary sparks visible by placing the resonator spark-gap within a glass tube, in which an explosive mixture of H and Cl is generated electrolytically. Even the smallest sparks can be rendered easily visible by the explosions they produce. (*Phil. Mag.* [5], xxxiii. 299.)

E. C. Rimington and **Wythe Smith** have attempted, with partial success, to show Hertzian oscillations by substituting a Geissler tube for the spark-gap in the resonator. (*Electrician*, xxx. 154.)

Specific inductive capacity.

A. Perot has made some measurements of the dielectric constants of spirit of turpentine, ice, resin, and glass, by a method based on M. Blondlot's demonstration that the period of the oscillations of resonators such as he employed in his researches is proportional to the square-root of their capacity (*see* p. 87). If, therefore, the wave-length of the resonator is determined first (λ_1) with air as the dielectric, then (λ_2) with a body the dielectric constant of which is κ, the relation holds $\sqrt{\kappa} = \lambda_1/\lambda_2$. The wave-lengths were determined by a Blondlot's oscillator by the method of a movable bridge. The resonator consisted of two strong square plates placed parallel to each other and connected to a micrometer spark-gap and a rectangular circuit. For turpentine the result found was $\kappa = 2{\cdot}25$. For ice the numbers lay between 60 and 71, a result confirming the high values found for the specific inductive capacity of ice by M. Bouty.

The measurements of the constants of resin and glass were made with periods of charge varying from 70 to 880 10^{-10} sec., and the results were compared with other determinations made by the prism method ("Year Book" for 1891, p. 78), and by the method of the ballistic galvanometer. The values of κ given by the prism method agree well with those found by the use

of the most rapid oscillations, especially in the case of glass, where κ varies from 2·39 to 6·10. This can be explained by the assumption that the residual charge is caused by the polarisation of electrolytic cellules scattered arbitrarily throughout the dielectric. The polarisation of these cellules has no influence on the direction of the lines of force, and thus does not affect the measurements. When κ is measured by the use of a condenser, the result increases with the duration of charge, and tends to a limiting value which appears to be equal to that given by the measurement of the deviation of equipotential surfaces. This value is to be considered as the true dielectric constant. (*Comptes Rendus*, cxiv. 1,528, and cxv. 38, 165.)

J. Lefebvre, in a communication to the Academie des Sciences, described experiments by a method based on Coulomb's torsion balance, in which the dielectric constant is measured by finding the repulsion between two balls when (1) there is only air between them, and when (2) a plate of the dielectric is interposed. He finds in this way the following values:—Sulphur, 2·6 to 3·9 (according to age, the value increasing with time); St. Gobain glass, 2·4 to 3·45; ebonite, 2·3; paraffin, 2; petroleum, 1·9; carbon bisulphide, 1·7; spirit of turpentine, 1·5. Lefebvre criticises a formula of Lord Kelvin's for the potential, at a point on the side of a dielectric plate opposite to a given charged point. (*Comptes Rendus*, cxiii. 688.)

In another place Lefebvre describes measurements of the attraction between two electrified plates separated by a dielectric, and verifies that it is expressed by the relation

$$F/F_1 = (e + e^1)^2/(e/\kappa + e^1)^2 ;$$

where F is the attraction of the two plates at a distance $e + e^1$ in air, F_1 is the attraction when the dielectric plate of thickness e and constant κ is interposed. The attraction was measured by a sensitive balance carrying one of the plates, which was provided with a guard-ring and suspended above the other fixed plate in dry air inside a cage. Observations were made with plates of sulphur and paraffin and some liquids which were held in a glass cell, a correction for which is made. A comparison of the results thus obtained with those found by the torsion balance method proves the formula to be correct, and shows that the method is a simple and rapid one for finding specific inductive capacities, requiring only a sensitive balance, and preferable to most other methods in use. (*Journ. de Physique* [3], i. 243.)

F. T. Trouton and **W. E. Lilly** describe a method of measuring specific inductive capacity by finding the force with which a plate

of a dielectric is sucked in between the plates of a condenser. The condenser is made in the form of alternate quadrants of a quadrant electrometer, and the dielectric in the form of a double fan-shaped needle suspended bifilarly. A formula is deduced connecting the dielectric constant with the deflection and the constants of the apparatus. The method is suited both to constant and to rapidly alternating electrifications. In the latter case an approximation may be made towards the instantaneous value of κ, and the method is particularly suited to this purpose. It is further claimed that the method avoids all doubtful approximate calculations, and when reduced in size it may be used for such measurements as the specific inductive capacity of crystals in different directions. (*Phil. Mag.* [5], xxxiii. 529.)

E. Cohn discusses the measurement of the dielectric constant of water by a method based on Hertz oscillations, by means of which the refractive index is obtained for very long wave-lengths, and then by Maxwell's theory κ is determined by the relation $\kappa = \mu^2$. The method was similar to that of Rubens (*see* "Year-Book" for 1891, p. 73), a portion of the wires being carried through a trough containing water. Movable bridges were arranged so as to make the resonance at the small Leyden jars a maximum at points in the parts of the wires in the air and in the water respectively, and the distances of the bridges gave the wave-lengths in air and in water respectively. By means of this arrangement it was found that for oscillations of some hundred millions a second the refractive index of distilled water is 8·6 at 17° C. Thus, by Maxwell's relation $\kappa = 73{\cdot}5$. The method also permitted of measurements of κ for watery solutions of salt up to a conductivity of $\lambda = 500 \times 10^{-10}$ referred to mercury. In these κ increases with increasing percentage of salt. The increase is about 7 per cent. on passing from distilled water ($\lambda = 7{\cdot}4 \times 10^{-10}$) to a solution of common salt of conductivity $\lambda = 455 \times 10^{-10}$. The observed constant κ of distilled water is accordingly identical within limits of errors of experiment with that of absolutely pure water. The refractive index of distilled water is in a very high degree dependent on the temperature. The decrease is about 7 per cent. in the interval from 9° to 35° C. The variation agrees well with Lorentz's relation $(n^2-1)/(n^2+2)d=$ constant, where d is the density. It is incompatible with either of the formulæ $(n-1)/d =$ constant, or $(n^2-1)/d =$ constant, which, within the narrow limits of the optical refractive indices, have done good service. (*Wied. Ann.*, xlv. 370.)

E. Bouty, utilising the fact that his method of measuring the dielectric constant of mica at high temperatures is applicable to

dielectrics having a small electrolytic conductivity, has applied the method to the investigation of the *coexistence of specific inductive capacity* κ *and electrolytic conductivity* ρ. The charge q of two rigidly fixed metallic plates is first found in air, then the plates are plunged into the dielectric conducting mass, and by the aid of a torsion pendulum the plates are connected for a known brief time t to the charging battery. The quantity of electricity Q is received and measured by a microfarad condenser. The relation $Q/q = \kappa + 4\pi t/\rho$ enables κ and ρ to be simultaneously determined. Owing to the high conductivity of water, its constant could not be measured in this way, but Bouty has determined that of ice, which at 0° C. has a resistance some 12,000 times higher than that of water. At − 23° C. ice was found to have the specific inductive capacity of 78, which remained much the same as the temperature increased, although the conductivity increased. The very high specific inductive capacity of ice is therefore beyond all question. It also follows from these experiments that dielectric power and electrolytic conductivity can co-exist in the same substance; moreover, the specific inductive capacity varies but little under conditions in which the conductivity increases enormously. Bouty has also applied the method to the study of good insulators, such as benzine, spirit of turpentine, and bisulphide of carbon mixed with a small proportion of absolute alcohol or ether. The addition of the conducting liquid raises the dielectric constant of the mixture nearly proportionately to its mass, so that it is legitimate to calculate its own constant by interpolation. Alcohol gives thus the value $\kappa = 8$, only about a third of that given by Cohn and Arons and Rosa. Ether gives $\kappa = 4{\cdot}8$, a value agreeing with that of Quincke.

From the point of view of specific resistance, the mixtures of alcohol and water present a remarkable peculiarity. The first traces of alcohol scarcely raise the conductivity, which then, although it increases rapidly, remains less than that calculated by the rule of mixtures. From this it may be concluded that the conductivity of alcohol arises, at least in part, from foreign bodies which are probably insoluble in pure benzine, and that therefore the superposed conductivity and dielectric power do not really belong to the same molecules. The same objection does not appear applicable to other experiments on the alkaline nitrates in the solid state, and especially on the mixture in equivalent proportions of nitrates of potash and soda. The experiments give a value of κ approximating to 4, and nearly invariable within limits of temperature in which the specific resistance varies in the

ratio 138 to 1. The conductivity in this case cannot be attributed to a superficial hygrometric layer, nor to impurities spread through the mass of the salt, for these, if they existed, would possess a conductivity of the same order as that of the salt itself. The conductivity and dielectric power belong, therefore, to molecules of the same kind. If experiments could be extended to ordinary electrolytes they would probably give similar results—that is to say, finite values of the constant κ. The distinction between dielectrics and electrolytes lies, therefore, solely in the order of magnitude of their conductivity. The dielectric polarisation, established in a time very short in comparison with a ten-thousandth of a second, would correspond in the scheme of Grotthus to the initial orientation of the composite molecules, their conductivity to their progressive rupture. (*Comptes Rendus*, cxiv. 533 and cxv. 1421; also *Journ. de Phys.* [3], i. 445.)

H. O. G. Ellinger, in order to investigate the dielectric constant of water and alcohol, measures the refractive index of a prism of the liquid for electrical waves by means of a Hertz apparatus with parabolic mirrors. The liquid was contained in a wooden prismatic box, 1·25 metre high. This was placed between the mirrors so that the axes of the latter made equal angles with the faces of the prism, and the angles were varied by moving the mirrors equally until the angle at which maximum resonance was obtained was found. In an experiment with a prism of 3° 45′ angle, containing about 50 litres of water, the sparks appeared when the axes of the mirrors made an angle of nearly 30° with each other. A small motion either way made the sparks disappear. This makes the refractive index of water for electrical waves about 9 (and $\kappa = 81$). Further experiments are being carried out by this method. (*Wied. Ann.*, xlvi. 513.)

In the "Year-Book" for 1891 (p. 80) reference was made to some experiments by **E. B. Rosa** on the specific inductive capacity of electrolytes. Prof. Rosa has since made further experiments on this subject. The method used is based on the consideration that force is exerted on a solid dielectric in a non-uniform electric field in an isotropic fluid medium, which varies with the relations between the specific inductive capacities κ and κ_1 of the fluid medium and solid dielectric. If κ is greater than κ_1 the solid is acted upon by a resultant force which urges it towards the stronger parts of the field. If, however, κ is less than κ_1 the solid tends to move towards those regions where the electric force is less. Thus glass would go towards the stronger parts of the field in air, turpentine and other dielectrics having a small value of κ, and towards the weaker regions in water and alcohol. More-

over, since κ for water and alcohol is very large, the glass would experience a force many times greater in water in the one direction than in the other.

To obtain an electrical field in which the intensity of the force varies in a known manner Rosa used two parallel wires oppositely charged. Two pairs of electrodes were employed, and in the two fields between the pairs two cylinders of the solid dielectric were suspended from the ends of the arm of a torsion balance. One electrode of each pair was joined to one pole of a battery furnishing any desired potential up to 140 volts; the other electrodes were joined to the other pole. A rotating commutator served to give alternations of 50 to 100 per second. Each cylinder was made to occupy a point in the field about a quarter of the distance between the axes of the cylindrical electrodes from the line midway between them. About this point of maximum force the field varies but little for a considerable distance, so that an exact knowledge of the position of the cylinders is not necessary. The deflection was measured by a telescope and scale, and the force determined in absolute measure.

The following is a brief statement of some of the results observed :—

(1) Glass cylinders in air, petroleum oils, bisulphide of carbon, turpentine, and benzine are attracted; that is, move into the stronger parts of the field.

(2) The force is least in air and greatest in turpentine.

(3) In water, alcohol, and ether, glass is repelled, the forces being nearly in the ratios of 9 : 3 : 1 respectively. In bisulphide of carbon, containing about 20 per cent. of the same ether, glass is attracted, but with about 40 per cent. it is repelled.

(4) The force of repulsion on glass in water is over 60 times as great as the attraction in air.

If the cylinder is a conductor, and is surrounded by a nonconducting medium, the resultant force is always an attraction. If the surrounding medium is a conductor the case is not modified, providing the solid is a very much better conductor. Thus suppose the cylinder is carbon, and the medium water, the lines of force will be arranged sensibly the same as though water were a nonconductor, and carbon a perfect conductor. The resultant force on the cylinder in a given field will evidently be proportional to the specific inductive capacity of the medium of the field. This is a much simpler case than that of a solid dielectric in a liquid, where the conductivity of the liquid and the specific inductive capacity of the solid affect the result. It would therefore seem an excellent method of measuring the specific inductive

capacity of liquids which are not too viscous. Accordingly measurements were made with cylinders of carbon (cut out of an arc-light carbon), mounted as above in the torsion balance, immersed in different liquids. The results obtained when calculated by the formula developed in the paper, gave the following values for the specific inductive capacity:—Water at 16°·5 C. 70; alcohol (about 93 per cent.), 30·9; ether (with water and alcohol impurities), 8·4; turpentine, 2·39; petroleum oil (300° test), 2·04; petroleum oil (light illuminating), 1·97. (*Phil. Mag.* [5], xxxiv. 344.)

C. Steinmetz, arguing from the analogy between the behaviour of dielectric bodies in an electrostatic field, and that of a magnetic body in a magnetic field, considers that in a dielectric medium subjected to alternating electrostatic stresses, as for example in the dielectric of a condenser which is alternately charged and discharged, the consumption of energy which occurs depends on the intensity of the electrostatic field, according to a law similar to that of magnetic hysteresis. Steinmetz has shown that in the latter case the loss of energy H in magnetisable bodies under alternating magnetic stresses is expressed by the formula $H=\mu B^{1\cdot 6}$. Experiments on condensers with paraffin paper insulation in an alternating circuit of 170 alternations per second led to the result that the energy consumed by the dielectric medium under alternating electrostatic stresses is directly proportional to the square of the intensity of the electrostatic strain; that is, it is proportional to the square of the electromotive force acting on the condenser or $H = \kappa\ E^2$. Thus while magnetic hysteresis follows the 1·6th power, the dielectric hysteresis follows a simple law of squares; that is, it acts just the same as a mere dead resistance. (*Electrician*, xxviii. 602.)

A. P. Chattock suggests an electrolytic theory of dielectrics, based on the phenomena of pyro- and piezo-electric in crystals. He assumes that chains of alternately positively and negatively electrified molecules occur parallel to the pyroelectric axis. The molecules tend to pair, but the pairing is resisted by mutual repulsion due to their mechanical heat motion. Changes of temperature or pressure, which alter the distances between the molecules, give rise to an alteration in the free charge at the end of each chain, and so produce pyro- or piezo-electricity. The existence of initially and oppositely charged molecules which is thus assumed, is then considered in relation to the general properties of dielectrics, such as cohesion, specific inductive capacity, and dielectric strength, and in each case, including pyro- and piezo-electricity, an approximate value for the mole-

cular charges is calculated. The fact that these all come out of the same order of magnitude as that of the charges carried by ions in electrolysis, is held as a support of the view that such charges exist. (*Phil. Mag.* [5], xxxiv. 461.)

Condensers; ratio of electromagnetic and electrostatic units.

W. L. Robb has made an experimental examination of the oscillations that occur in charging a condenser. The method which was used to obtain small times of charging was suggested by Prof. H. F. Weber. Two steel spheres were arranged in contact, one was stationary, the other was suspended from a fine wire. The condenser was charged by allowing the small sphere to swing against the larger and rebound. The length of time of contact was varied by varying the size of the smaller sphere, the number of times the spheres were brought into contact, or the velocity of the smaller sphere. Although the first experiments are simply qualitative in their character, it can be concluded as a result of the observations that oscillations in the charge of a condenser occur during the charging, and that the amplitude of these oscillations diminishes rapidly as the time increases, and may be increased either by diminishing the resistance, or by increasing either the electromotive force, the self-induction, or the capacity. Subsequent experiments of a qualitative character, in which the condenser was charged by a Helmholtz pendulum, confirmed the first results. (*Phil. Mag.* [5], xxxiv. 389.)

Lord Kelvin, in a communication to the Royal Society, describes a new form of air leyden, or air condenser, which has been devised for the purpose of enabling measurements to be made with the aid of a suitable electrometer of small electrostatic capacity. It consists of two systems of square brass plates, the members of each system being bolted together at the four corners, so that the plates are parallel and at equal distances apart. One system rests on three vulcanite feet, the other rests by means of the hole, slot, and plane arrangement on three glass columns attached to three metal screws, which can be adjusted so that the plates of this system are exactly midway between and parallel to those of the first system. (*Proc. Roy. Soc.*, lii. 6.)

H. Abraham has made a redetermination of the ratio v of the electromagnetic and electrostatic C.G.S. units of electrical quantity. The method adopted was that of measuring experimentally in electromagnetic units the capacity of a condenser, the electrostatic measure of which is calculated from the linear dimensions of the condenser. For the purpose of the research a standard air condenser with a capacity of 500 C.G.S. electro-

static units was specially constructed. Two circular discs of St. Gobain plate glass, 2·3 cm. thick and 35 cm. diameter, were silvered on the faces and edges. The opposing faces were accurately planed before silvering. One plate was supported horizontally on cloth pads resting on paraffin supports. The silvered surface of the other plate was divided by a circular cut, 0·1 mm. wide, into a collecting plate and guard-ring. Contact with the collecting plate could be made by a conical hole in the centre of the glass plate. This hole was silvered and stopped with an accurately-fitting silver plug, to which the connecting wire was attached. The guard-ring plate was separated from the other by three accurately-turned quartz washers. These afforded excellent insulation. The insulation resistance of the condenser was over 80,000 megohms. With the width adopted for the guard-ring (8·5 cm.) the correction for the edge is less than $\frac{1}{50000}$, even when the plates are 1 cm. apart. From the results of five series of concordant measurements of v made with this condenser, the mean value $299{\cdot}2 \times 10^8$ is arrived at. This value is considered correct to $\frac{1}{1000}$ part. (*Journ. de Phys.* [3], i. 361.)

Electrolysis and electrolytic resistance.

A. Schuster and **A. W. Crossley**, in a paper read before the Royal Society, show that the reason why deposits of silver obtained in vacuo are somewhat larger than in air at ordinary pressure is to be ascribed to the influence of dissolved oxygen, for when the electrolysis was carried out in an atmosphere of oxygen the deposits were less than those obtained in air. In the experiments, platinum bowls 5 inches and 3½ inches in diameter were used, and a consistent difference of about 0·02 per cent. was obtained in favour of the larger bowl. Some experiments seem to show that when anodes of the same size are used this discrepancy disappears, confirming the impression of the authors that the effect may possibly be due to secondary products formed at the anode when the current density exceeds a certain value. The results of similar experiments in vacuo were not very concordant, but the average deposits were heavier in the larger bowl. The electrochemical equivalent of silver as deduced from electrolysis in vacuo was almost identical with that obtained from Lord Rayleigh and Mrs. Sidgwick's deposits from hot solutions. The experiments showed a small but constant polarisation of seven millivolts, which was the same in air and in vacuo. The authors conclude from their experiments that the true electrochemical equivalent of silver is probably not quite one part in 1,000 greater than the value given by Lord Rayleigh. (*Electrician*, xxix. 326.)

C. Ludeking has made a series of experiments on the action of the electrical discharges of an induction coil on gases and vapours. Water vapour offers great resistance to the passage of the sparks as compared with air. In the gases collected from the + and — terminals an excess of oxygen is found in the former, and of hydrogen in the latter. Hydriodic-acid vapour is readily decomposed, the + pole becoming coated with iodine, but a great part of the decomposition is due to thermal dissociation by the sparks. Ludeking considers that a pure gas is not electrolytically conducting, but that by the thermal dissociation caused by the sparks a mixture of gases is formed which conducts fairly well so that electrolysis may then take place. The electrolytic conduction is not simultaneous with the passage of the sparks and consequent thermal dissociation. He concludes that the decomposition is in part a true electrolysis after the manner of a Grotthus chain, as assumed by E. Wiedemann and J. J. Thomson. The hydrocarbon gases, olefiant gas, marsh gas, and coal gas, yield deposits of carbon the greater part of which grows on the + pole in the form of a fine hard brittle conducting filament, toothed regularly with sharp cones projecting towards the — pole. That on the — pole is soft and sooty. The former indicates a true electrolysis, the latter a thermal dissociation which in amount is far inferior to the former. The volumes of the olefiant gas and marsh gas increase with the sparking to double the original volume, so that decomposition is probably perfect. This experiment contrasts curiously with that in which acetylene is produced by the discharge between carbon electrodes in hydrogen. It would seem that acetylene is itself decomposed when one or both of the electrodes are metals. No carbon filaments are formed by the discharge in chloroform or carbon tetrachloride vapours, and in both cases the decomposition is complex. The volume of carbon bisulphide vapour rapidly diminishes, the deposits are equal on both poles, and the decomposition appears to be a purely thermal one. Carbon bisulphide vapour offers enormous resistance to the discharge. Silicon tetrachloride is not acted on by the discharge, and attempts to electrolyse the vapours of the haloid compounds of mercury were without success. It would seem, finally, that some of the phenomena are true electrolyses in part; others seem to be only thermolyses; that is, the compounds are simply dissociated by the heat of the discharge. It is very difficult to separate the two actions, and the phenomena indicate that in most cases they go hand in hand. (*Phil. Mag.* [5], xxxiii. 521.)

L. Arons has made an experimental investigation to test

whether a metallic partition in an electrolytic cell can be made so thin that the electrical polarisation on its opposite faces can be suppressed. A voltameter filled with dilute sulphuric acid and containing platinum electrodes was divided by a glass plate down the middle into two divisions. In the glass plate there was a circular hole 1·5 cm. diameter, over which a thin diaphragm of pure metal (Pt. Au. Ag.) was fastened. The voltameter formed a simple circuit with a galvanometer and from two to five secondary cells. With a platinum plate 0·1 mm. thick, the deflection of the galvanometer fell, and a strong development of gas took place on each side of the plate. With a partition of pure gold-leaf, fastened to the plate with Canada balsam, the galvanometer deflection remained unchanged and no development of gas occurred. This was also the case when silver-leaf was used instead of gold.

To test the effect of possible holes in the film a hole, 3 mm. diameter, was made in the platinum foil. There was still a strong decrease in the current and a considerable formation of gas on the foil. A four-fold thickness of gold-leaf gave a small diminution of the current. To compensate the decrease resistance was removed from the circuit. The resistances in ohms which it was thus necessary to remove in the various cases were as follows:—Platinum foil, 19; platinum foil with hole, 5; four-fold thickness of gold-leaf, 0·25: gold-leaf and silver-leaf, 0. (*Wied. Ann.*, xlvi. 169.)

G. Kümmell has made a series of experiments on the separation of precipitates at the boundaries of electrolytes under the influence of an electrical current. By the use of gelatinised solutions, or solutions separated by partitions of pure gelatine, he shows that the precipitate at the boundary is formed by convection of solid particles by the current from the negative pole. The fact that it forms first nearest to the walls of the tube is in agreement with Quincke's demonstration that the convection proceeds more rapidly near the walls of the tube than in the middle. The stoppage of the precipitate at the boundary is explained by the fact that the convection takes place only in badly-conducting liquids. (*Wied. Ann.*, xlvi. 105.)

Willy Bein has carried out a large series of experiments on the velocity of the wandering of the ions in a dissolved electrolyte through which an electric current is passed. (*Wied. Ann.*, xlvi. 29.)

W. C. Dampier Whetham has communicated to the Royal Society a full account of his experiments on ionic velocity noticed in the "Year-Book" for 1891, p. 85. (*Nature*, xlvii. 164.)

K. R. Koch and **A. Wüllner** have made an extended examination of the effects of polarisation at small electrodes. They find that a considerably increased polarisation appears with short platinum wire electrodes in dilute sulphuric acid. The polarisation consists of an opposing E.M.F. and a transition resistance. The former is independent of the length of the wires, and with the 1 per cent. solution employed is not dependent on the concentration of the solution. The latter has the value to which the polarisation of plates approximates with increasing current density, viz.: 3·79 volts. For a given electrode and solution it is independent of the current strength. With given electrodes it is proportional to the specific resistance of the solution, and with a given solution it diminishes considerably with increase of length of the wire electrodes. The above statements only hold, however, for a certain current strength which is dependent on the length of the wire electrodes and conductivity of the solution. If this strength is exceeded there occurs a strong increase of the polarisation and a corresponding strong decrease of current, resulting in a feeble residual current the strength of which is not increased by further increase of E.M.F., the effect of which is only to produce an increase of the polarisation. The strength of this residual current is greater for longer wire electrodes than for shorter ones, it also appears to be greater when the decrease of current sets in through increase of the O polarisation than when it arises from increase of the H polarisation. After its appearance, when it is dependent on increase of the polarisation at the anode, the anode is quickly corroded, glows vividly, and is subjected to great internal stress, which at times causes it to split. When the increase of polarisation arises at the cathode, a gaseous envelope surrounds the cathode, which shines with a bluish-white light. With increase of E.M.F. this surrounds the whole wire, which then glows, but without showing internal stresses like those of the anode.

Zinc electrodes in $ZnSO_4$ and copper electrodes in $CuSO_4$ both show increase of polarisation with increase of current density. At the anode a sudden rise of polarisation occurs at a given current strength. At a Zn anode this rise appears to increase with increase of current, and proportionately to it; at a Cu anode it changes little with the current, and assumes a stable value within certain limits of the current. This large polarisation can also be obtained at larger anode surfaces with smaller current density, if it has previously been produced at a small part of the surface, by means of a larger current density. (*Wied. Ann.*, xlv. 475, 759.)

Lagrange and **P. Hoho** have made somewhat similar experiments with copper electrodes in 10 per cent. sulphuric acid solutions. With sufficient increase of E.M.F. bubbling and boiling occur at the negative electrode, next intermittent arcs take place between the wire and liquid, and finally a luminous cylinder is formed, having the copper wire for axis. The current then becomes steady, and the resistance very high. Similar effects were obtained with platinum, zinc, tin, iron, steel, and carbon electrodes of different diameters, with sulphuric acid solutions of different strengths, and with chloride of sodium solution. The production of the luminosity is accompanied by an abnormal resistance which is localised round the − electrode. The shape of the − electrode appears to have little influence. Luminous effects can be obtained, but with more difficulty, at the + electrode. They cannot, however, be obtained simultaneously at both poles. (*Bull. de l'Acad. Roy. de Belg.* [3], xxii. 205.)

L. Houllevigue has examined the polarisation of electrodes of platinum in a solution of sulphate of copper under the action of E.M.F.s approaching those at which the salt commences to be electrolysed. He finds that a definite and distinctly marked maximum of polarisation occurs in the neighbourhood of the point at which electrolysis begins. This phenomenon has previously been observed by himself in the case of mixtures of salts, and by Chaperon with electrodes of Pt in acidulated water, and of Mg in potassa solution. It is therefore general. He explains it by the gradual growth of isolated crystals of copper on the electrodes. The polarisation of these crystals is small, and thus the mean polarisation is diminished. It is thus possible to fix the point at which electrolysis commences, by observing at what E.M.F. the curve of polarisation abandons its straight direction to bend downwards towards the axis of E.M.F.s. (*Journ. de Phys.* [3], i. 385.)

R. Lohnstein, with the view of investigating the electrical conductivity of electrolytes by a method eliminating the effects of polarisation, has made a series of experiments on the passage of very weak currents through the electrolytic cells, the currents being produced by the inductive action of a swinging magnet on a coil of wire forming part of the circuit. When these currents passed through the electrolyte between electrodes of the metal contained in the solution, and the resistance of the circuit was estimated by the logarithmic decrement or damping of the vibrations, the damping showed the presence of an apparent transition resistance at the surface of separation of the electrodes and electrolyte. This resistance depends on the condition of the

electrodes, and is very considerable if they are bright and smoothly polished. It is lessened by coating the electrodes with an electrolytic layer of the metal, and can be made to disappear more and more in proportion as the layer is looser and more pulverulent. The amalgamation of freshly-polished surfaces of metal acts in the same way. In this way the transition resistance may be made to vanish completely; when this has been attained, very weak currents can pass through the liquid cells as if through an ordinary metallic resistance, and neither polarisation nor transition resistance occurs. (*Wied. Ann.*, xlvii. 299.)

A. W. Reinold and **A. W. Rücker** described at the meeting of the British Association a curious property of thin liquid films with respect to their electrical resistance. A film of aqueous soap solution containing glycerine has a specific conductivity which is much greater than that of the liquid in bulk. The thinnest films have a resistance seven times as great. When, however, a small proportion of a metallic salt, such as K_2SO_4, is dissolved in the solution, the resistance of even the thinnest films is the same as that of the liquid in mass.

The voltaic cell.

E. F. Herroun has examined the E.M.F.s of platinum-zinc and gold-zinc cells with the view of determining the relative positions of Pt and Au in Volta's tension series. In modern text books Pt is placed after Au, but according to thermo-chemical data Au should be more negative than Pt, at least in chloride solutions, and in those in which oxygen is the attacking medium. A Zn-Pt cell was made in which the Pt electrode was immersed in a neutral solution of $PtCl_4\ 2\,NaCl$, and the Zn electrode in $ZnCl_2$, both solutions containing ·25 equivalent of the salt in 100 of water. The E.M.F. from thermo-chemical data is 1·543. The observed E.M.F., which was very variable, ranged from 1·7 to 1·473. The average 1·525 is a little lower than the calculated, but the difference is small, and there seems to be no reason to assume that the actual E.M.F. departs from the theoretical value. A Zn-Au cell was similarly set up with solutions of $ZnCl_2$, and $AuCl_3$ of the same concentration as before. The theoretical E.M.F. is 2·044; the observed E.M.F. ranged from 1·834 to 1·855. The constancy of this cell was in marked contrast to the variability of the Zn-Pt cell. Assuming the thermal values to be correct, the actual E.M.F. is thus 0·2 volt below the calculated, or, according to the convention of Wright and Thompson, 0·2 volt is the thermo-voltaic constant for gold in a dilute neutral solution of its chloride. (*Phil. Mag.* [5], xxxiii. 516.)

J. Brown, in a paper read before the Royal Society, refers to

the discrepancies which exist between the observed E.M.F.s of cells and their theoretical values calculated from thermo-chemical data. As these discrepancies are probably caused by the action of the solvent, Brown has submitted to examination a series of cells with fused electrolytes formed by all possible combinations of the metals Ag, Cu, Sn, Pb, Cd, Zn, in their chlorides, and of Ag, Cu, Sn, Pb, Fe, Cd, Zn, Al, and Mg, in their double alkaline chlorides. The cells were made by fusing one of the electrolytes in a V tube, into one limb of which a short straight tube plugged below with asbestos and containing the other electrolyte, was inserted. The appropriate metals were placed in their chlorides in the tubes, and the E.M.F. was compared by an electrometer with a standard Daniell's cell. To avoid complication in the calculation of the theoretical E.M.F., the chlorides employed were either both single or both double. The observed E.M.F.s were found to agree fairly well with the calculated, especially in the case of Zn, Pb, Sn, Al, and Mg. The agreement was rendered very much closer when certain corrections were made. The physical cause underlying these corrections is believed to be connected with the higher temperature of the experiments as compared with those at which the heats of combination were obtained. This view was confirmed by experiments on cells containing only a single chloride fused in the V tube, with a piece of the metal contained in it inserted in each limb and connected to a galvanometer. On heating one limb more than the other a current was produced in all cases except Cd, the hotter metal being the — pole. Metal was transferred from the hot to the cold pole, showing the electrolytic nature of the phenomenon, and suggesting, in the light of Thomson's law, an increase with temperature of the combining heats of the metals with Cl together with a possible Peltier effect. Four of the cells were tested by passing currents through them in both directions alternately, and noting the E.M.F. after the passage of each current. Polarisation was observed to a small extent in one case Zn-Ag; in the others it was practically absent. (*Proc. Roy. Soc.*, lii. 75.)

W. Negbaur also, with the view to avoid the secondary effects, caused by the solvent, has made an extensive examination of cells formed with solid electrolytes, such as the haloid salts of Pb, Ag, and Hg. The electrodes were of Pt, Hg, Cu, Ag, Pb, or Zn, and were made in the form of wires wound into a flat spiral and squeezed in a small press against the ends of compressed blocks of the electrolytes. The E.M.F. of the cells was found to change only slightly with the temperature. Changes of molecular structure, such as from amorphous to crystalline, did

not appear to have any decided influence on the E.M.F. Observations of a cell with varying proportions of water showed that in the transition from solid dry salt to a concentrated solution, the E.M.F. changed gradually without showing any characteristic points.

Negbaur enters into an elaborate discussion of the relation of his results to Lord Kelvin's law, by which the E.M.F. is calculated on the basis of the conservation of energy from the thermochemical actions in the cell. This law is undoubtedly true, in so far as the E.M.F. is to be regarded as a function of the chemical actions of the cell. But in most cells only a fraction of the chemical energy is converted into electrical energy, the rest remains as heat of secondary processes. Only those combinations are suitable for the verification of the law in which the latter portion of energy is zero. Helmholtz has concluded that in the case of those reversible cells in which the local heat development is zero, and the useful effect is unity, the E.M.F. must be independent of the temperature. This conclusion has been verified, and in addition Negbaur finds that a few non-reversible cells must also be independent of the temperature, since they show unit useful effect. Thus the cell Pb | PbI_2 | Zn has the observed E.M.F. 0·201 volt; while its calculated value is 0·202 volt, and it is non-polarisable. Of the constant cells only three, Ag | Ag R | Pb R | Pb, where R is either Cl, Br, or I, gave unit useful effect. In these the whole chemical energy changes into electrical, and they are (theoretically) independent of the temperature. (*Wied. Ann.*, xlvii. 27.)

M. Maclean, at the British Association meeting, described some experiments which generally confirm Lord Kelvin's law that a feeble continued current passing out of an electrolytic cell by a Zn electrode must generate exactly as much more heat at the Zn surface, than the same current would generate in passing out of the electrolytic cell by a Pt electrode, as a Zn-Pt pair working against great external resistance would develop in the resistance wire by the same amount of current. Experiments made with Zn-Zn and Zn-Pt electrodes in dilute sulphuric acid showed that the rise of temperature of the Zn-Zn cell was greater than that of the Zn-Pb cell, and the average rise was in agreement with the above law. It was also found that the rise of temperature was greater at the Zn anode than at the Zn cathode plate. When external currents were sent through cells Zn-Zn, Pt-Pt, Pt-Zn, Zn-Pt, the rise of temperature was in all cases higher in the cell in which the current flowed from Pt to Zn, than when it flowed from Zn to Pt. (*Electrician*, xxix. 435.)

G. P. Grimaldi describes a curious property of a bismuth cell, formed by immersing electrodes of bismuth in dilute hydrochloric acid or a solution of chloride of bismuth. If one of the electrodes be subjected to a strong magnetic field, a current flows the direction of which in the liquid is from the magnetised electrode. The E.M.F. varies with the electrodes and with the solution. In a field 81,500 times that of the earth's horizontal component, it may reach ·0023 of a Daniell. (*Il Nuovo Cimento*, xxv. 191.)

J. Brown gives in the *Philosophical Magazine* an account of an incompleted research on the difference of potential at the contact of mutually reacting liquids. The method was a modification of Exner and Tuma's. A water-dropping funnel connected to one terminal of a quadrant electrometer had its nozzle alternately within one of two cylinders of filter-paper moistened with the two liquids. The cylinders were connected either by a strip of paper across which the liquids soaked till they met, or by an arrangement of funnels permitting a continuous renovation of the surface of contact of the two liquids. One of the cylinders was earthed, and the potentials of the two cylinders were compared with that of the water-dropping funnel by means of the electrometer.

Experiments on strong solutions, one of which was raised from a lower to a higher oxide or chloride by the inter-action, showed that the effect could not be deduced from the oxidation of a metal by an electrolyte, for in most cases the effect was the opposite, the oxidised or chlorinated substance being +.

Experiments on the effect of contact of two solutions between which double decomposition occurred on mixing, did not give very concordant and reliable results. In so far, however, as the results may be considered as approximate, they give the following conclusions:—(1) There is no clear connection apparent between the observed E.M.F.s and the heat equivalents of the reactions; but the amount of water present seems to have an effect, either by dilution of both solutions equally, or of one more than the other. (2) The sign of the electrification may depend, however, on the following considerations. When double decomposition occurs at the contact of solutions of two substances, one of which consists of an anion a and a cation c, and the other of an anion a' and a cation c', the products of the reactions being ac' and $a'c$, then the solution ac will be + if the combining heat $a'c$ is greater than the combining heat ac'; and *vice versâ*.

Experiments on series of pairs in which acids and strong aqueous solutions were in contact with water showed, in the case

of positive heats of solution or dilution, a rough agreement between their amounts and the observed E.M.F.s, but in the case of negative heats the results were indefinite. The results negative the hypothesis that "water must show against every electrolyte the potential of the faster ion." (*Phil. Mag.* [5], xxxiii. 532.)

G. Gore, in a research on "A general relation of E.M.F. to equivalent volume, and molecular velocity of substances," has shown, by means of an extensive series of sixty-four tables of measurements of mean volta E.M.F., that the dilution of a liquid of a voltaic cell by means of water or alcohol, the liquefaction of either the + or — metal of the cell by means of mercury, the dilution of either of these amalgams by means of mercury, or the dilution of one solid metal by means of another in an alloy, is universally attended by an increase of mean E.M.F. of the diluted and diluting substances beyond the calculated amount, and consequently also of the actual E.M.F. of the diluted one (that of the diluent being very little affected), provided that in all cases no chemical union or other chemical change occurs in the mixture. If, however, chemical union does occur, this gain of E.M.F. is diminished, or converted into a loss which is larger in proportion as the union is more intimate. The manifest explanation of this extensive general result is that by the act of solution or dilution, the molecules of the active or diluted substance are separated further apart and consequently acquire increased velocity of motion. The method enables chemical compounds in alloys, amalgams, and electrolytes to be distinguished from mere mechanical mixtures. (*Proc. Birm. Phil. Soc.*, viii. 63; also *Phil. Mag.* [5], xxxiii. 28.)

Th. Des Coudres examines the question whether an E.M.F. exists between differently curved mercury surfaces in a solution of a salt of mercury; or, in other words, whether a constant galvanic cell can be set up from mercury in different states of compression in a solution of a salt of mercury. On the basis of the law of conservation of energy, and independently of any special theory of electrical processes, he shows that this question can be answered affirmatively, and a numerical estimate of the E.M.F. can be formed. By calculations based on the equality of the electrical and mechanical work done in the transfer of mercury from a less curved to a more curved surface in a solution of a salt of mercury, it can be shown that at the ordinary temperature the E.M.F. for a difference of pressure of one atmosphere is about 15·3 microvolts. Nernst's theory of the electromotive activity of the ions leads to the same conclusion.

In a series of experiments in a solution of nitrate of mercury with a capillary electrometer, the following results were obtained :—

Pressure in cm. of Hg.	36	40	42	46	52	113
Deflection, obs., scale divs.	2·8	3·6	3·6	4·0	5·0	7·8
,, calcd. ,, ,, ...	2·7	3·0	3·2	3·5	4·0	8·7

The scale divisions were such that 38 corresponded to an E.M.F. of 0·0001 volt.

These results present general agreement with the formula, but the observed values at higher pressures are always lower than the calculated. Suggestions are offered as to the cause of this difference. (*Wied. Ann.*, xlvi. 292.)

G. Kummer discusses experimentally the so-called "agitation currents" (*Erschutterungsströme*), which are formed as follows. When two exactly similar metals dip into a liquid which chemically acts on them, or through contact with them suffers chemical decomposition, there forms on both plates of metal a fine coating of newly formed chemical products. If this is entirely or partially removed by agitation of one of the electrodes, the two electrodes become electrically dissimilar, and a current flows the direction of which depends on the nature of the newly formed layer. By formation of an oxide the current flows from the agitated to the stationary electrode; whilst the direction is the reverse in the presence of a layer of hydrogen. Kummer's experiments were made on plates of Cu, Ni, Cd. Zn, and Ag, each pair being first carefully tested as to their electrical similarity. One of the plates was attached to a metal rod, and by means of an electromagnetic interruptor could be maintained in a state of rapid vibration. The E.M.F. was measured at intervals until the maximum value was reached, which in some cases required several hours. The metals collectively show by the change in their electromotive behaviour a change of their surfaces, produced by immersion in the liquid, which is not always perceptible to the eye. The effect of the agitation acts in two ways: (1) by promoting increased solution of the surface layer at the agitated electrode—the stationary electrode is then the − pole; (2) when the solution goes on so slowly that only the neighbouring layers of fluid are changed, while the surfaces of the electrodes remain electrically similar, a concentration current arises and the stationary electrode is the + pole. Both of these actions may be superposed. (*Wied. Ann.*, xlvi. 119.)

The secondary cell.

A considerable amount of attention has been paid of late to

the chemistry of the secondary cell. The following gives a summary of some recent work on this subject.

G. H. Robertson, in a communication to the Royal Society, arrives at the conclusions that :—

(1) Neither chemical nor electrical tests give any grounds for supposing that any other sulphate than the ordinary white sulphate $PbSO_4$ is concerned in the interactions occurring in the cell.

(2) Were the sudden lowering of the E.M.F. caused by a change in the nature of the chemical compounds formed on the plates, it is difficult to account for the rapid recovery of the E.M.F. exhibited by an apparently charged cell.

(3) Peroxides are formed in appreciable quantities in the electrolyte during charge and discharge, and their influence must not be neglected in considering the behaviour of the cell.

(4) It is to the electrolyte, rather than to the plates, that attention must be directed if any considerable improvement is to be effected.

H. E. Armstrong and **G. H. Robertson** further conclude that—

(5) The cooling is probably due to the dissociation of the dilute sulphuric acid. As the values found are in practical agreement with those calculated on the assumption that the acid used is sulphuric acid itself, H_2SO_4, in all probability such acid, and not the dilute acid contained in the cell, is operative throughout.

(6) The observed loss in efficiency cannot be due to temperature changes, as these arise through actions occurring out of circuit.

(7) It is difficult from a comparison of calculated with observed values of the E.M.F. to arrive at any final conclusion as to the exact nature of the changes which take place in the cell. (*Proc. Roy. Soc.*, i. 105, 108.)

In a paper read before the Society of Arts **G. H Robertson** shows that the electrolysis of dilute sulphuric acid, as shown by Berthelot, gives rise to the formation of persulphuric acid, which in its turn gives rise to hydrogen dioxide in larger and larger proportions as the cell remains at rest. To the presence of these bodies Robertson ascribes the variations of E.M.F. which occur in secondary cells. Electrolysed acid can be shown to be capable of decomposing lead peroxide. This appears to explain the deleterious effect of rest on the cell, for although persulphuric acid itself does not reduce peroxide of lead, it forms hydrogen dioxide on standing, which is capable of oxidising the lead plate to litharge, or reducing the peroxide plate to the same substance.

Introducing hydrogen dioxide into the body of the peroxide

paste of a cell, to represent the condition of a cell which is started discharging directly the charging is completed, produced a small increase of E.M.F. Its addition to the acid of the cell produced a great diminution, or even a reversal, of E.M.F. Thus the variations of E.M.F. appear to depend at which plate the hydrogen dioxide is formed at. When present diffused through the acid, and present at the lead plate, it causes a lowering of the E.M.F., and the rise in E.M.F. sometimes noticed on starting the discharge of a cell which has been at rest is probably due to the electrolysis and decomposition of hydrogen dioxide; for in a cell which has long been idle, practically the whole of the active oxygen is due to this body. (*Journ. Soc. Arts*, xl. 44; *Electrician*, xxviii. 176.)

J. H. Gladstone and **W. Hibbert**, on the other hand, have come to the conclusion that variations in the strength of the sulphuric acid are the main cause of the variations in E.M.F. After discussing the variations which occur in the strength of the acid at the lead and lead peroxide plates during the various stages of charging, discharging, and repose, the authors describe numerous experiments, in which plates of pure lead and pure peroxide of lead were immersed in various strengths of acid, which show that the E.M.F. developed is a determinate function of the strength of acid at both plates. The variations thus produced more than cover the range observed in cells in working.

The curves of changes of E.M.F. of secondary cells are shown to be consistently explained by the supposition that the changes are due to the variations of strength of the acid. To confirm their views, Gladstone and Tribe describe experiments showing that if two lead plates are placed in acid of different strengths, separated by a porous partition, the lead in the weaker acid behaves to the other like a PbO_2 plate. Also with two peroxide plates, the one in the weaker acid behaved to the other like a lead plate. Thus the effect of increasing the strength of acid round a PbO_2 plate is the opposite of that of increasing it round a Pb plate. Increasing it round both plates should therefore give potential differences which are the arithmetical sums of the separate effects, and these are found to agree closely with the potential differences experimentally found when Pb and PbO_2 plates are placed together in varying strengths of acid. Further confirmations are drawn from the changes which occur in the resistance of a secondary cell during the various stages of charging and discharging, and from thermo-chemistry. With respect to the great weight which Professor Armstrong and Mr. Robertson attribute to the presence of peroxides in the electrolyte, Gladstone and Hibbert

have made experiments on the effect of adding hydrogen dioxide to the electrolyte surrounding both Pb and PbO_2 plates, and have been able to detect only such alterations as could fairly be attributed to the dilution of the acid. They have also charged a pair of plates in a divided cell filled with 20 per cent. acid, and have found that the peroxides existed only round the PbO_2 plate. On then reversing the plates in their compartments the fall of E.M.F. was but slight, from 2·185 to, at first, 2·163, and after 45 minutes to 2·031, and is only such as would occur normally in acid of 20 per cent. strength. Also adding persulphate of potassium to the acid about a PbO_2 plate had no visible effect on the E.M.F.

Gladstone and Hibbert conclude, therefore, that the E.M.F. depends on the acid strength of the electrolyte, and not on the existence or position of peroxidised bodies in it. (*Journ. Inst. Elect. Eng.*, xxi. 412, and *Electrician*, xxix. 67.)

In the discussion on the above paper **G. H. Robertson**, speaking for himself and for Professor Armstrong, referred to the cooling of the acid during discharge, of which Gladstone and Hibbert's theory gave no explanation. It appeared difficult to attribute this to any other cause than dissociation consequent on the withdrawal from the solution, either of molecules of H_2SO_4 itself or of molecules which were only slightly hydrated; in other words, they considered that the formation of lead sulphate took place, not at the expense of the acid of the concentration in contact with the material undergoing change, but at the expense of free molecules of H_2SO_4 present in the acid liquid, the withdrawal of which occasioned the appearance of a fresh supply with concomitant cooling. In their paper in the *Proceedings* of the Royal Society, Armstrong and Robertson advanced reasons for concluding that a counter-E.M.F. probably exists, due to the peroxides which are always present. Further consideration led them more and more to favour the view that a considerable counter-E.M.F. was operative throughout discharge, which was conditioned by the peroxide in solution at the lead peroxide plate. (*Electrician*, xxix. 119.)

G. Darrieus, in an "Essay on the Chemical Theory of Lead Accumulators of Electricity," controverts the view that sulphating occurs at both plates, which he holds is contrary to Faraday's law. Experiment shows that after discharge there is always a relation between the total quantity of peroxide reduced and the ampere-hours, but none between the sulphate of lead formed on this plate and the latter. On the −plate the lead sulphate formed shows close agreement with the amount required by

theory. Darrieus considers that the primary action of discharge is the formation of some oxide. He ascribes the high initial E.M.F. to the joint action of the small quantity of occluded hydrogen in the lead plate, and the persulphuric acid which is formed at the PbO_2 plate; while the energy furnished during the steady part of the discharge is attributed to the reduction of the peroxide and oxidation of the lead plate. In both cases sulphating follows from local action.

The action of the persulphuric acid formed during charge is to bring the whole of the active material to the peroxide state, and Darrieus points out that unless the conditions are such that the existence of this body is possible, peroxide of lead is not formed by electrolysis.

The theory of double sulphating appears to have been adopted because it brings Lord Kelvin's law into harmony with the results of experiment. At the commencement of discharge the law is in practical harmony with observed values, whether H_2O or H_2SO_4 be regarded as the electrolyte, if the presence of persulphuric acid be allowed for. But during the steady portion of discharge the discrepancy is great. Darrieus attributes the want of agreement to the physical state of the lead plates, and points out that both Schutzenberger and Gore have shown that certain metals, amongst which is lead, are not obtained in their normal state by electrolysis, and that they give out heat in passing into it. (*Bull. Soc. Internat. des Elect.*, ix. 88, 205; *Electrician*, xxix. 359.)

Gladstone and **Hibbert** attribute the finding by Darrieus of oxide of lead on the + plate to the difficulties of analysis, as it is hard to imagine that oxide of lead could remain as such when surrounded by sulphuric acid. They reply to Armstrong and Robertson's criticisms of their views, and describe fresh experiments to show that the increase of E.M.F. does not depend on the presence or absence of persulphuric acid. In the first experiment a Pb and a PbO_2 plate were placed in a 12 per cent. solution of pure H_2SO_4, and separated by a porous diaphragm. The E.M.F. was 1·945 volt. One per cent. of persulphate of potassium was then placed in the acid surrounding the PbO_2 plate. The E.M.F. remained at 1·945 volt. The Pb plate was then placed in the same compartment as the PbO_2 plate, so that both were exposed to the action of the persulphuric acid. The E.M.F. fell only to 1·934 volt. In the second experiment a cell was made with phosphoric acid in place of sulphuric, and results were obtained with it analogous to those obtained with sulphuric acid. (*Electrician*, xxix. 173.)

F. Streintz, in Part IV. of a series of "contributions to the

theory of secondary cells" in *Wiedemann's Annalen,* demonstrates the formation of superoxyhydrate of lead, H_2PbO_3, in the cell. This is only to be regarded as a secondary product. Its formation results in a decrease of potential difference in charging, its destruction by a decrease on discharge.

With respect to the dependence of the E.M.F. on the strength of the acid, the examination of twelve experimental cells of the Tudor type showed that the E.M.F. increased proportionately with the strength of acid, the curve of variation being nearly straight. Excluding those cells in which the concentration exceeded 500 gm. in 1000 cc. of liquid the following formula holds :—$E_s = 1{\cdot}850 + 0{\cdot}917\ (S - S_0)$, where E_s is the E.M.F. for a specific gravity S, and S_0 is the specific gravity of water at the temperature of observation.

The temperature coefficient of the cell is +, and is greatest with a density of 1·16, or acid strength of about 20 per cent. by weight. Between the limits of E.M.F. 1·983 and 2·010, and of density of acid 1·144 and 1·173, the temperature coefficient is given by the parabolic equation $\delta E/\delta T = 357 \times 10^{-6} - 0{\cdot}64\ (E - 1{\cdot}998)^2$. Outside these limits the coefficient is considerably smaller than this formula would indicate. (*Wied. Ann.*, xlvi. 449.)

M. Kügel attributes the self-discharge of the negative plates of a secondary cell to the metallic impurities in the acid. At the commencement of the charge the electro-negative elements in the acid are precipitated upon the negative plates. They there set up local action, hydrogen appearing at the electro-negative metal, and oxygen at the adjacent lead sponge. The latter oxidises the lead, and deteriorates the working of the cell. Good plates which have a normal capacity in pure acid, when once the deleterious metals have been precipitated on them in impure acid, are not improved by being again placed in chemically pure acid. (*Electrician*, xxix. 148.)

Electrical resistance of metals.

J. Dewar and **J. A. Fleming** have availed themselves of the possession of means at the Royal Institution for producing considerable quantities of liquid oxygen and ethylene, to carry out some investigations on the comparative electrical resistance of a number of pure metals, alloys, and non-metals at the low temperatures obtainable by the evaporation of liquid oxygen at ordinary barometric pressures (−182° C.), and the ebullition of liquid oxygen under reduced pressures of about 25 or 30 mm (−197° C.). Since liquid oxygen is a very perfect insulating fluid, the wire or the rod of the metal may be simply immersed in it, and be thus at the same temperature as the liquid. The resistances

were also measured at 100°, 20,° 0°, − 80° (ether and solid CO_2), and − 100° C. (liquid ethylene boiling under atmospheric pressure). Data are thus obtained for plotting a series of curves, taking absolute temperatures as abscissæ and specific resistance as ordinates. The curves of resistance tend downwards in such a way as to show that if prolonged beyond — 200° C. they would probably pass through or near the origin or absolute zero. The curves can be divided into three classes:—(1) those of metals such as iron, nickel, tin, and perhaps copper, which are concave upwards; (2) those of metals such as gold, platinum, palladium, and probably silver, which are concave downwards towards the axis of temperature; and (3) those of metals such as aluminium, which are apparently nearly straight lines. In the first class the rate of change of resistance with temperature *increases* as the temperature rises; in the second class it *decreases*. This has previously been observed by Prof. C. G. Knott between 0° and 300° C. Dewar and Fleming's results show that the distinction between the metals of the two series extends over a very large range of temperature. Clausius made the suggestion in 1858 that the electrical resistance of a pure metal is proportional to its absolute temperature. Owing to the marked curvature of the resistance-temperature lines this statement is only very approximately true for a few metals, and not at all for others, but it yet remains not improbable that the electrical resistance of all pure metals would at the absolute zero be either null or exceedingly small.

Impurities in the metals considerably modify the decrease of resistance. The resistance of pure iron at — 197°C. is about $\frac{1}{23}$ of that at 100°C., and of pure copper about $\frac{1}{11}$. Absolutely pure nickel prepared by Ludwig Mond's process has a resistance of about 12,000 at 0°C., and 1,900 at — 182°C.; but a nickel wire supposed to be pure gave as corresponding values 13,387 and 6,737.

The resistance lines of alloys, when the constituent metals are chemically very different (platinum-silver, platinoid, German-silver), are very nearly straight, with but little slope, not one-tenth that of the pure metals. When, however, the constituents of the alloy are chemically similar (platinum-iridium, platinum-rhodium) the resistance-lines slope down at a much steeper angle, but never, as in the case of the pure metals, in such a manner as to indicate that if prolonged they would pass through the absolute zero. The lines for impure metals are in position more or less like the lines for alloys formed of similar metals.

The behaviour of carbon is peculiar. The specific resistance

of carbon filaments of incandescent lamps *increases* continuously with reduction of temperature. Dewar and Fleming have not yet completed the examination at similar low temperatures of the resistance of non-metals such as sulphur and selenium; and the quasi-metals arsenic and antimony. Also the behaviour of insulators, such as glass, mica, guttapercha, india-rubber, remain to be examined. As the electrical resistance of these bodies decreases with rise of temperature, it may prove to be the case that pure non-metals approach a maximum specific electrical resistance, and pure metals a minimum specific electrical resistance, in proportion as the absolute zero is approached.

Finally, Dewar and Fleming give the values of the mean coefficient of resistance-change a between 0° and — 100°C. for the following metals:—Ag, ·00384; Al, ·00390; Cu, ·00410; Fe, ·00531; Pt, ·00354; Sn, ·00509; Ni, ·00500. If R_t is the resistance of the metal at t°C., and R_o its resistance at o°C., then we may write: $R_t = R_o (1 + at)$.

From these values of the coefficients it is seen that iron and nickel have pre-eminence in respect of rate of fall of resistance with temperature. It is a striking illustration of the effect of great cold on electrical conductivity, to realise that at the temperature of boiling liquid oxygen pure iron conducts electricity better than the purest copper does at ordinary temperatures. (*Phil. Mag.* [5], xxxiv. 326.)

C. E. Guillaume, commenting on Dewar and Fleming's experiments, points out that owing to the uncertainty of the measurement of very low temperatures, the first results of the experiments will be to furnish a thermometric scale, and not the function which connects resistance with temperature, for this latter variable is unknown. As long as it is not proved by the theory of gases that the hydrogen thermometer is worthy of confidence below — 200°C., the best means of measuring these temperatures will be the variation of the electrical resistance of some concordant metals, their variation being determined at known temperatures comprised between + 300°C. and — 150°C., a little more if possible, and extrapolated below. Guillaume points out that the temperature which Dewar and Fleming indicate as — 197°C. is probably really somewhat lower, approximating — 200°C. (*Electrician*, xxix. 699.)

In the *Comptes Rendus* (cxv. 414) **C. E. Guillaume** describes the results of renewed investigations on the thermic variation of the electrical resistance of mercury. From these results the apparent resistance of mercury in glass expressed as a function of the

normal scale of temperatures is as given in the following table:—

Temperature T.		0°	10°	20°	30°	40°	50°	60°
Resistance	(a)	1·00000	1·00890	1·01801	1·02731	1·03682	1·04653	1·05644
	(b)	1·00000	1·00891	1·01803	1·02734	1·03685	1·04656	1·05646

(a) and (b) were obtained by two different methods of measuring the resistances. The real variation of the specific resistance of mercury expressed as a function of the normal scale is—

$$(a)\ P_T = P_0(1 + 0{\cdot}00088745\,T + 0{\cdot}0000010181\,T^2).$$
$$(b)\ P_T = P_0(1 + 0{\cdot}00088879\,T + 0{\cdot}0000010022\,T^2).$$

A. Oberbeck discusses in *Wiedemann's Annalen* the peculiar behaviour of silver films to an electrical current. Silver deposited chemically on glass has at first an extremely high resistance, which gradually diminishes, but does not reach a constant value even after some years. In seeking an explanation of this peculiarity Oberbeck has examined the allotropic modifications of silver described by Carey Lea. Like Barus and Schneider, he finds that the so-called dissolved or finely suspended silver in water (Lea's "colloidal" silver) does not conduct electrically, unless dried. The gold and blue modifications of silver are excessively sensitive to moisture, which increases their resistance, whereas drying decreases it. Both possess at first a high resistance, which decreases with time. This peculiarity of silver films may be due to incomplete coherence of fine particles, or to the existence of allotropic modifications of silver. For the latter hypothesis there is a preponderating number of arguments, or at least for the proposition that the conductivity is chiefly conditioned by molecular modifications of silver. All actions which cause allotropic silver to approximate to ordinary silver improve the conductivity. Oberbeck discusses at length the conductivity of a large series of modifications of silver, and the influence of heat, light, chemical actions, moisture, and mechanical deformations in modifying the conductivity. (*Wied. Ann.*, xlvi. 264, and xlvii. 353.)

Thermo-electromotive force.

H. Bagard, in a short communication to the *Comptes Rendus* (cxiv. 980), shows that the thermo-electric phenomena at the contact of two electrolytes exhibits the same features as the majority of bimetallic couples. Thus with a couple formed by a solution of 115 grammes of zinc sulphate in 100 grammes of water, and a solution of sulphuric acid of $\frac{1}{1000}$ part by weight, the cold

sulphate of zinc is the + pole externally, and the curve connecting thermo-electromotive force and temperature is of parabolic form, concave upwards. When the second liquid was a solution of 30 grammes of copper sulphate in 100 grammes of water, the warm sulphate of zinc is the positive pole externally. The curve descends at first, then ascends again, thus presenting, as before, its concavity upwards. The absolute value of the thermo-electromotive force increases at first, then passes a maximum value at about 40°, and decreases to zero at about 70°, to increase again with reversed sign.

MAGNETISM.

By P. L. GRAY, B.Sc., A.R.C.Sc.

Theory, &c.

J. Ewing discusses the magnetic screening effect of iron under the influence of alternating currents. (See also "Year-Book" for 1891, p. 96.) Electrical engineers are already familiar with the direct effect of eddy-currents in causing a dissipation of energy, and the consequent necessity of laminating iron when it is exposed to the influence of rapidly-alternating magnetic forces. But there is also this magnetic screening effect exerted upon the interior of any iron plate or wire in the magnetic circuit, in consequence of which it is necessary to apply a stronger external magnetic field in order to force the mean induction up to an assigned value —stronger, that is, than if there were no screening, which occasions two indirect losses—first, the loss due to the augmentation of hysteresis, and, second, the loss due to the necessary increase in strength of the magnetising current.

If the plates of the core are thick, virtually only a small part of the thickness is used; the rapid changes of polarity only take place in a mere *skin* of the metal, and the magnetism has no time to penetrate far between consecutive reversals. The influence of this screening is surprisingly great—*e.g.*, when plates of soft iron are exposed (as the plates in a transformer-coil are) to alternating magnetic forces of moderate strength, and, say, 100 per second in rapidity, the metal in the middle of the thickness only experiences $\frac{1}{8}$th of the force applied to the skin. If the iron be 1 mm. thick, this fraction becomes increased to 52 per cent., with the same rapidity.

The loss ceases to be serious, so far as magnetic screening is concerned, when the thickness is made $\frac{1}{2}$ mm., while, to prevent

serious loss due to eddy-currents, the thickness should be $\frac{1}{4}$ mm. But in that case the non-magnetic space becomes too greatly increased; so that, as a compromise, the thickness of ·35 mm. used by good makers of transformers is justified by theory. (*Electrician*, xxviii. 631.)

J. Ewing, in a paper on "Joints in Magnetic Circuits," discusses the effect of a plane of transverse section in an iron bar which forms part of a magnetic circuit. Such a "joint" introduces "magnetic resistance," even if the faces of the section are as nearly as possible true planes, and in good mechanical contact. When very considerable forces are applied in bringing the surfaces together, the magnetic resistance vanishes—as, indeed, we should *à priori* expect.

Some figures obtained in 1888 (*Phil. Mag.* [5], xxvi. 274) made it appear that the width of the equivalent air-gap in magnetic resistance decreased as the magnetisation was forced up to high values. This, however, is incorrect; the width remains nearly, if not quite, constant, whether the magnetisation is weak or strong. (*Phil. Mag.* [5], xxxiv. 320.)

J. Trowbridge has made experiments to test the possible "Wave-Propagation of Magnetism." When one end of a steel or iron bar is magnetised, how is the magnetism propagated so that in a very short time the whole bar is magnetised? Various attempts have been made to solve this problem, generally by subjecting iron to alternating currents of certain frequency, and searching for *nodes* along the length of the bar (or ring), with small secondary coils of wire, and a ballistic galvanometer or telephone.

Mr. Trowbridge uses a new instrument, which he calls a *phasemeter*, consisting of two telephones, with a mirror affixed to the diaphragm of each, the arrangement being such that a spot of light reflected from both mirrors (as in Lissajou's well-known tuning-fork experiments) reproduces the figure produced by a combination of two motions at right-angles. The iron ring used was 3 feet in diameter, and $\frac{1}{2}$-inch diameter of cross-section. Two large coils of thick wire were slipped on the ring, to convey the alternating current. Two small coils of fine wire were also placed on the ring, each connected with one of the telephones. If the two large coils were so placed that their equivalent magnets would have poles of the same name opposite, a small coil placed half-way between them indicated no lines of force passing through it; therefore, the telephone connected with it would receive no motion, and on the screen the spot of light would describe merely the straight line due to the motion of the diaphragm of the other telephone, under the influence of the

second small coil. With poles of the opposite name opposed, no change of phase was observed, the lines of force going in the same direction in this case anywhere between the large coils, so that the position of the first small coil between them was immaterial. The writer comes to the conclusion that nothing corresponding to a true wave-propagation of magnetism through the iron could be detected, although the molecules quivered under the influence of the periodic alternations of magnetism to which one part of the metal was subjected—the process being somewhat similar to the propagation of heat along a bar. (*Phil. Mag.* [5], xxxiii. 374.)

C. Fromme continues his account of his "Magnetic Investigations." In previous papers he had shown that identically similar pieces of iron and steel may, by different methods of magnetisation, be brought to have the same magnetic moment and distribution of poles, and yet have very distinct molecular arrangements, and also that the rapidity with which the magnetising force is reduced has a marked effect on the permanent magnetism of the specimen. In the present paper he describes experiments on iron bars and bundles of wires, and distinguishes between the results obtained (*a*) by a sudden break of the magnetising current, (*b*) by a slow decrease of the same, (*c*) by jars and shocks, as affecting the temporary and the permanent magnetism.

In the case of bundles of wires (*b*) and (*c*) gave similar results, but with iron bars the results differed. Different rates of diminution of the magnetising current had also different effects on both the temporary and the permanent magnetism.

The writer explains his results by assuming differences of grouping of the molecular magnets, any number of ways being conceivable, without the exterior effect being altered. Breaking the circuit breaks up the grouping in a totally different manner from that in which a gradual diminution of current acts; knocking and sudden jars produce similar effects to breaking circuit. It seems not unlikely that the sudden motion of the molecular magnets, caused by a sudden cessation of the magnetising force, may give them a certain velocity which carries them, as it were, past a certain normal position, when their mutual actions cause a different grouping from that which might result from their being allowed *gradually* to assume the normal position by a slowly-reduced current. The stability of molecular groups is less in bars than in bundles of wire. (*Wied. Ann.*, xlv. 798.)

The magnetic properties of different substances.

A. Abt describes some experiments on the magnetic properties

of magnetite. He used two bars of loadstone, about $4'' \times 1'' \times \frac{5}{8}''$, one (A) fine-grained and rather porous, the other (B) with yellowish veins and particles of malachite scattered throughout its mass. (A) contained 17·5 and (B) 61·4 per cent. of iron. The pieces were compared with steel of different kinds, no absolute measurements being made. The permanent magnetism of (B) was always greater (three or four times) than that of steel, for all values of the magnetising force; the ratio diminished as the force increased. The permanent magnetism of (A) was also greater than that of steel, but the temporary magnetism was always less (·1 to ·3). Demagnetising was also tried, and it was found that the magnetite showed much less hysteresis than steel. (*Wied. Ann.*, xlv. 80.)

In the *Electrician* (xxix. 475) there is a note on the magnetic properties of aluminium-iron, which, it says, differ little from those of ordinary cast-iron.

A. Banti has made some experiments on the "Magnetisation of Nickel, Especially when Subjected to Mechanical Stress." It was already known that a magnetic body, under a certain amount of torsion, and at a certain critical mechanical tension and strength of magnetic field, has its polarity reversed as the torsion is lessened.

The author experimented with nickel wires 30 cm. long and 1·2 mm. in diameter, and obtained the following results :—

In a nickel wire in a magnetic field of certain strength and stretched with a sufficient weight, and then twisted and untwisted, the sign of the magnetisation alternates with every cycle of torsion. No certain relation between the stretching weight required to produce reversal and the strength of the field could be proved. Indeed, the same wire when new required a greater load than when old for the same strength of field. At the critical angle of torsion the wire had apparently no magnetisation. The initial condition of the wire, with regard to elastic stretch, etc., had a great influence on the later result. (*Beiblätter*, xvi. 556, and reference there.)

S. Henrichsen describes some experiments on the magnetic properties of some organic compounds—*e.g.*, propyl-alcohol, amyl-chloride, etc. He compared the susceptibility of the different substances with that of a solution of chloride of iron, and concludes, from the results of a long series of experiments, that the susceptibility is constant for different values of the magnetising force, and also gives its absolute values. (*Wied. Ann.*, xlv. 38.)

J. Dewar has been continuing his interesting researches on the

properties of liquid oxygen, ozone, air, etc., which he began last year. He liquefies air at the ordinary atmospheric pressure by utilising the intense cold of liquid oxygen. Both the nitrogen and oxygen of the air liquefy together, although after a little while the nitrogen begins to boil off first. Liquid air, like liquid oxygen, adheres to the poles of a magnet. It is interesting to note that Becquerel announced in 1849 that if the magnetic susceptibility of iron be taken = 1,000,000, then that of oxygen would be = 377, and of liquid oxygen = 1,000. (*Electrician*, xxix. 169.)

C. Decharme has been making some "Experiments on Various Methods of Magnetising Steel," with a view of deciding whether a bar of hard steel can be more strongly magnetised by placing it within a helix of wire traversed by a current in the ordinary way, or by inserting a soft-iron core in the latter and using it as an electromagnet with which to rub the steel bar. The author shows that with bars of ordinary steel, inserting it in the coil, and so making a direct use of the current, gives the slightly better effect—6 to 8 per cent. But for producing transverse magnetisation the reverse is the case, with a much greater difference. The most powerful method of magnetising is that of Elias, in which the steel bar is used to complete the circuit of an electro-magnet, and a coil moved to and fro along it. (*La Lum. Elec.*, xliii. 155.)

C. Decharme has also been investigating the "Effect of Local Heating on Permanent Magnets." The effect of high temperature on the whole of a permanent magnet was known before. Gaugain, *e.g.*, raised a magnet to a blue-tempering temperature, and found that the magnetism first increased and then diminished, and that repeatedly raising the magnet to 150° C. and cooling it again altered the distribution of its magnetism. Also, according to Wiedemann and Trowbridge, the magnetism of the bar is lessened by lowering its temperature below the point at which it was magnetised.

In making local differences of temperature, the author found that raising either end, or the middle of the bar, to a "blue" temperature, had no effect on its magnetism. The method used was to place the permanent magnet in a fixed position with respect to a delicately-pivoted compass-needle, and observe the rate of oscillation of the latter, which made 25 vibrations per minute in the ordinary field of the earth alone. When the magnet (a rod 22·5 cm. long, 1 mm. in diameter) had its N. pole directed towards the needle, the latter made 34 oscillations per minute. After the N. pole of the rod had been heated to redness, and

allowed to cool slowly, the number became 26, showing that the magnet had become much weaker.

The diagram obtained with iron filings showed apparently that the N. pole had not diminished much in intensity, but that it had become pushed back, as it were, so that practically it was at a greater distance from the needle. The neutral point was also nearer the S. pole than before.

Another bar, raised to a dull red heat at the middle, showed some weakening of the poles, and a slight shift of the neutral point.

Heating one pole and then the other destroys nearly all the magnetism. If heated in the middle, the magnetism seems to shift to the poles, and not to be destroyed until the poles are bright red. When both poles are heated simultaneously, the magnetism rapidly diminishes, and finally vanishes.

Pieces of steel magnetised transversely, and then heated at either one end or the middle, lose nearly all their magnetism in the heated part. (*La Lum. Elec.*, xliii. 258.)

W. Kunz, in a paper on the "Effect of Temperature on Hysteresis," shows that, with equal magnetic induction, the loss due to hysteresis distinctly diminishes with an increase of temperature. In one piece of soft iron the loss per c.c. was 23,490 ergs when cold, 19,180 at 530° C. (dull red), and 21,640 when cold again. A specimen of steel showed a diminution of loss from hysteresis of 20 per cent. when raised to a temperature of 100°C. (*Elektrotechnische Zeitschrift*, xiii. 245.)

Effects of magnetisation.

Shelford Bidwell has a paper "On Changes Produced by Magnetisation in the Length of Iron and other Wires Carrying Currents." Changes of length are known to be related to several other phenomena of magnetisation, *e.g.*, a twist is produced in an iron wire which is magnetised circularly and longitudinally at the same time. Clerk Maxwell considered that this was explained by an expansion along the spiral lines of magnetisation; but Wiedemann considers the explanation inadequate, and believes the phenomenon to be an effect of unequal molecular friction.

A close connection had already been shown by Prof. Knott between the phenomena of twist and those of elongation and contraction. Since the magnetic elongation is known to be diminished by tension, the conclusion may be drawn from his work that in an iron wire carrying a current the magnetic elongation would be increased, and the experiments described in the paper were undertaken to test this point. The results show that the prediction was true, and strongly confirm Maxwell's explanation of the twist mentioned above.

The apparatus and methods of observation were the same as those described in former papers. The wire in each case was 10 cm. long between its supporting clamps, and the magnetising coil, 3 lbs. in weight, was supported by the wire itself. The indications of the instrument were read to $\frac{1}{100000000}$ part of the length of the wire, which was demagnetised by reversals of the current before each observation. Similar experiments were made with nickel and cobalt; in the former the action of the current was practically insensible, and in the latter it was very slight.

As an example of the results, we may take the following:—Wire of soft commercial annealed iron, ·75 mm. in diameter. Magnetic field due to the coil 30 c.g.s. units; elongation of wire with no current through it, ·00000010 cm.; with one ampère of current, ·00000014 cm., and with two ampères, ·00000020 cm. (*Proc. Roy. Soc.*, li. 495.)

E. van Aubel has made some new experiments on the "Influence of Magnetisation on the Length of a Bar of Bismuth," which is a diamagnetic substance. Shelford Bidwell (*Proc. Roy. Soc.*, xliii. 408) had found an apparent change of length, which, in his opinion, could not be accounted for by the trace of iron present in the bismuth as an impurity. Dr. van Aubel uses an optical method, in which any expansion of the bar under examination is rendered measurable by means of changes in the interference-fringes produced by a sodium-light in a film of air contained between a fixed prism and a plate of glass which is fastened to one end of a lever connected with the bar of bismuth. The bar was 31 cm. in length, and is described as "absolutely pure." The sensitiveness of the arrangement was such that a change of length of ·0000016 mm., or (for the 20 cm. within the magnetising coil) an alteration per unit length of ·00000008 mm., could be detected. Now Mr. Bidwell obtained an apparent expansion *twice as great* as this, while Dr. van Aubel failed to observe any alteration at all, so that it is probable that a bar of *pure* bismuth does not alter in length under the influence of magnetisation. (*Jour. de Physique* [3], i. 424.)

C. Knott describes some experiments on "Certain Volume-effects of Magnetism." The effects measured were the changes of the internal capacity of 5 iron and 5 steel tubes. Each tube was closed below, and, while under experiment, also closed above, by a screw-nut, through which a capillary glass tube passed, the whole being placed vertically within a magnetising coil. The whole of the metal tube, and part of the capillary tube, were filled with water and the change of volume was shown by the

motion of the meniscus in the capillary bore. The measurements were made by means of a micrometer microscope.

The tubes were all 18 inches long, and $1\frac{1}{2}$ inches external diameter; the interior diameters of both sets respectively were $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1 and $1\frac{1}{4}$ inches. The observed changes of volume amounted to as much as 5×10^{-4} c.c. In the thinnest-walled tubes the volume at first diminished when the field was small, then increased with higher fields. In the thicker-walled tubes the capacity at first diminished and then began to increase, but never attained its original value. With the intermediate tubes very irregular results were obtained, which do not seem to follow any clear law, and it is evident that further experiment is necessary before any general statement on the point can be made. (*Electrician*, xxix. 430.)

T. Andrews publishes a continuation of his investigations on "Electro-chemical Effects of Magnetising Iron." The effect studied was the difference of corrosive action of a solution of cupric chloride on bars of steel magnetised and unmagnetised. The bars varied in length from 3 to $4\frac{1}{2}$ inches, and in diameter from ·25 to ·3 inch.

In any single experiment two pieces of about these dimensions were cut from the same finely-polished rod; one of them was magnetised, the other was left unmagnetised. They were then weighed and put into separate beakers containing equal quantities of cupric chloride of the same strength. The bars were left in the solution for several hours, and then re-weighed. In every case the magnetised steel was the more corroded, to a mean extent of about 3 per cent. on the total loss of weight. The cause of this difference probably lies in "the local electric currents set up by magnetisation between the polar and central portions of the bar, inducing somewhat greater chemical action." (*Proc. Roy. Soc.*, lii. 114.)

Magnetic instruments, &c.

J. Ewing showed an extremely interesting "Magnetic Curve Tracer" at the Edinburgh meeting of the British Association in August, 1892. An account of it may be read in the *Electrician*, xxix. 385, and also in *Nature*, xlvi. 552.

It is an apparatus for automatically drawing magnetic curves—that is, curves showing the relation between the strength and direction of a magnetising force, and the magnetisation produced by it. Prof. Ewing had obtained these characteristic curves before by the slow process of plotting down on squared paper the results of a number of actual measurements. The curve is obtained by reflecting a spot of light from a mirror, which is so mounted that

it receives a horizontal motion proportional to the magnetising force, and a vertical motion proportional to the magnetisation produced by this force in the specimen of iron or steel under examination. The spot of light traces out the curve on a sheet of squared paper, or, if required, on a sheet of sensitised photographic paper.

A complete cycle, giving the familiar "hysteresis curve," may be gone through in a fraction of a second, so that if repeated rapidly the curve appears continuous on the screen, but in general use it would be performed more slowly, so as to allow the curve to be traced by following the spot of light with a pencil.

The arrangement of the apparatus is as follows:—A wire is stretched in a narrow gap between the closely-opposed pole-pieces of a magnet made of the iron whose properties it is required to investigate; through this wire a constant current passes, and when the magnetising current is sent round the coils of the magnet, this wire (in which the *constant* current is passing) moves up and down according to the variations of the magnetism in the magnet. This gives vertical motion to the mirror. The horizontal motion is obtained in a somewhat similar manner from a wire stretched in a narrow longitudinal slot in a permanent bar magnet, which wire forms part of the magnetising circuit—that is, is connected in series with the coils carrying the magnetising current, so that it has a variable current through it, and is in a constant magnetic field (which is just the opposite of the case of the other wire), and its motion produced on this account indicates the variations of the magnetising force, and gives horizontal motion to the mirror.

The instrument may be made practically useful for very rapid workroom tests, etc. It may also be employed as a phasemeter, or as a dead-beat galvanometer.

A more detailed account of the instrument in its latest form will be found in the *Electrician*, xxx. 64.

H. E. J. G. du Bois, also at the British Association meeting, gave an account of his "Magnetic Balance, and its Practical Use." This is another instrument designed to test the magnetic properties of samples of iron. The test-piece is made in the form of a bar of certain dimensions (arranged to facilitate calculation, and the calibration of the instrument), and is supported horizontally between two massive vertical uprights, which form the poles of the magnet when the current is passed through the coil round the test-bar.

Above these uprights a "yoke," nearly semicircular and formed of the best Swedish iron, is balanced eccentrically, so that when the bar is magnetised a turning movement is exerted on this

yoke, owing to the unequal leverage on its two segments, and it tends to move on its axis of support until one end rests on the pole-piece beneath it. This is prevented by moving a weight along a horizontal scale attached to the yoke, until equilibrium is again established.

The end of the semicircular yoke is prevented from ever touching the pole-piece by stopping against an insulated screw-point fastened to the pole-piece, so that a small air-gap is always left, and the weight is altered in position until it just pulls the yoke off this insulated contact-screw.

The instrument is calibrated experimentally, and the contact-screw is enclosed in a cap to prevent subsequent alteration. From the readings given by the different positions of the weight on the scale, curves are obtained giving the relations between the magnetising force and the magnetisation produced in different specimens. (*Electrician*, xxix. 448.)

W. Hibbert has made and patented a piece of apparatus for the production of a Permanent Magnetic Field. Magnets as a rule show a continual decrease of strength as their age increases, the rate of diminution of magnetic moment becoming slower and slower as time goes on. For some purposes it is useful to obtain as nearly constant a field as possible, and the arrangement of Mr. Hibbert's apparatus for this purpose is as follows :—

A cylindrical steel rod, $2\frac{1}{4}$ inches long and 1 inch in diameter, is attached to two cast-iron pole-pieces. The upper pole-piece is a circular disc, 4 inches in diameter and $\frac{5}{8}$ inch thick, fitting by a hole in its centre on the upper end of the magnet. The lower pole-piece is nearly hemispherical, and is screwed on to the lower end of the magnet, which stands up in it as in a basin. This pole-piece is of such dimensions that the top of the "basin" is level with the top of the disc, and a circular air-gap, less than $\frac{1}{16}$ inch in width, is left between them. In this narrow ring-shaped air-gap the magnetic field is found to be practically constant. A thin ring-shaped coil is so arranged that it may be made to fall through the air-gap; in so doing a current is induced through it, which is measured in the ordinary way, and the constancy of the field proved. In one instrument there was no evidence of loss of magnetic moment in seven months. Neither did vigorous blows produce any appreciable effect, which was to be expected, since the fall of the coil many hundreds of times, with the consequent shocks, was also inoperative in producing any decay of strength. (*Phil. Mag.* [5], xxxiii. 307.)

M. Marcher describes an ingenious "Exploring Needle for Magnetic Fields;" it consists of a thin steel tube, closed at each

end by a thin iron disc, and magnetised. A glass tube has a bulb blown at one end rather greater in diameter than the length of the magnet, and the bore of the tube is large enough to allow the magnet to slip down it into the bulb, which is filled with a liquid whose specific gravity is such that the hollow magnet will float anywhere in it in equilibrium. The tube is closed with plaster close down to the bulb, and the magnet will then indicate the direction of the lines of force at any position in which it may be placed. The steel tube should be as light as possible, and works well in a liquid of about ·7 or ·8 specific gravity. (*La Lum. Elec.*, xliv. 236.)

Terrestrial magnetism.

The year has been marked by several great "magnetic storms," the apparent connection of which with sun-spots and exceptional displays of the *Aurora Borealis* has again been made manifest, although the mechanism of the connection is as little known as ever. The disturbance of February 13th and 14th was particularly noticeable, most observatories in different parts of the world giving some account of its effects. (See also page 137.)

M. Moureaux (*Comptes Rendus*, cxiv. 352) says that this was the most violent "storm" observed at Parc St. Maur (Paris) during the last ten years. It began suddenly at 5.42 a.m. (Paris time) with an increase of declination and horizontal force, and a decrease of vertical force. This agrees exactly with the record obtained at Kew, or at least as nearly as the accuracy of the time-scales can be trusted. The most important phase of the disturbance occurred between 11 p.m. and 2 p.m., the spot of light at the maximum divergence from the normal value being thrown off the recording paper, so that absolute values were unobtainable. (The same thing happened at Kew and at most other observatories, the strips of paper not being wide enough for such exceptional records.) The storm ceased at about 5 p.m., after some hours of vibratory motion in all the magnets. The maximum disturbance in declination was approximately 1° 25′; while the horizontal and vertical forces altered by $\frac{1}{37}$ and $\frac{1}{88}$ respectively of their normal values. The curves obtained on the same days at seven other French observatories show an exact simultaneity in the disturbances, and a perfect agreement in every detail.

An important group of sun-spots had appeared on the 5th and remained clearly visible for many days, and although M. Jannsen does not consider the correlation between the phenomena proved, the general consensus of opinion runs in the other direction. It should be mentioned, however, that Lord Kelvin

has more recently given figures which tend to make the accuracy of this general view doubtful.

Displays of the *Aurora Borealis* were numerous and exceptionally brilliant during the storm in New York on the night of 13–14, and over nearly the whole of Europe, while at the same time strong earth-currents made telegraphic work in many cases impossible, not only in Europe, but also in America, India, and Australia.

The superintendent of the United States Naval Observatory (letter in *Nature*, xlv. 493) confirms the remarkably *sudden* commencement of the storm at 12.40 a.m. (about 7.40 Greenwich time) on February 13th, with an increase of declination and both horizontal and vertical force. The maximum disturbance in the first was about $1\frac{1}{2}°$, while the horizontal force varied $2\frac{1}{2}$ per cent.; the vertical magnet was upset by the violence of its motion, and the record therefore lost.

H. Wild (*Comptes Rendus*, cxiv. 565) compares the record of the disturbance at Pawlowski with that obtained at Paris. According to him, the perturbations commenced at the two places at practically the same time, but in the opposite direction for all the elements—a very curious fact. The normal declination at Pawlowski was then about 0° 5′ W.; during the storm it varied between 1° 27′ W. and 1° 47′ E.

Another very disturbed period occurred about March 11th–13th, and in *Nature* (xlv. 557) **M. A. Veeder** points out the coincidence of the recurrence of such phenomena with the period of a synodic revolution of the sun. He also maintains that solar disturbances have the greatest effect in producing terrestrial electric and magnetic disturbances when they occur at the east limb of the sun, and near the latitude of the plane of the earth's orbit.

M. E. Marchant, on the other hand (*Comptes Rendus*, cxiv. 410), considers that spots have the greatest effect when they are crossing the sun's central meridian. Many more observations will have to be made before this point can be considered settled.

A later paper by **M. Ricco** is based on the curves obtained at the Washington Observatory, and in it he compares the times of greatest disturbance with times of transit of large spots or groups of spots across the central meridian of the sun's disc. *Assuming* that this position of a large spot is that in which it causes the maximum terrestrial magnetic disturbance, the figures obtained indicate a velocity of the influence, whatever it may be, from the sun to the earth, of less than $\frac{1}{300}$ of the velocity of light. The very serious difficulty involved in granting the possibility of an entirely new velocity of this order to the passage of any influence

or wave-phenomenon through the ether makes it extremely doubtful whether the assumption at the root of the reasoning is correct; and, in fact, our knowledge on the obscure points involved is too limited at present to allow of any exact generalisation as to the connection between the phenomena in question. (The paper will be found in the *Comptes Rendus*, cxv. 595.)

G. F. Fitzgerald, in commenting on M. Ricco's paper, remarks that the difficulties of imagining a direct electro-magnetic propagation as the cause of these disturbances, do not exist if we assume instead a discharge from the sun of highly-charged molecules, such as are assumed in one theory of comet-tails. Such a stream may leave a sun-spot at some angle with the perpendicular to the surface, so that a "lag" of the terrestrial disturbance behind the meridian-passage of a spot might be accounted for. (*Electrician*, xxx. 48.)

W. Ellis has a paper connected with this subject, "On the Simultaneity of Magnetic Variations at Different Places on Occasions of Magnetic Disturbances, and on the Relation between Magnetic and Earth-current Phenomena." He discusses the ordinary diurnal variation, etc., and points out a close simultaneity in the beginnings of sharp disturbances at widely-separated observatories.

Seventeen days, between 1882 and 1889, were selected for comparison of the records obtained at Greenwich, Toronto, Pawlowski, Mauritius, Bombay, Batavia, Zi-ka-wei, and Melbourne, and for a few days in 1882 and 1883 at Cape Horn. The mean difference in time between the disturbances discussed varies from + 2·4 to − 2·9 minutes, the agreement between Greenwich, Pawlowski, Mauritius, and Bombay being very close. The question arises, Are these differences real, or due to accidental error, arising, for instance, from the ordinary smallness of the time-scale? But even if they are real, the close coincidence is none the less very remarkable and interesting. He notices the curious point that the movements are not always in the same direction at different observatories, and concludes with a comparison of some magnetic and earth-current records. (*Proc. Roy. Soc.*, li. 445.)

PHYSICAL ASTRONOMY.

By E. W. MAUNDER, F.R.A.S.

The year 1892 presented not a few features of more than usual interest to the student of astronomy. Of these, three stand forward beyond all the others, each one sufficient in itself to give

ance during February of the largest sun-spot observed since 1871; the photographic study of the spectra of the chromosphere and prominences has continued, in the skilful hands of Hale and Deslandres, to bring fresh information to light; the various planets—Venus, Mars, Jupiter, and Saturn—have proved most interesting objects of scrutiny; improved photographs of the moon have increased our knowledge even of its familiar surface; the long roll of minor planets has undergone a more rapid addition in consequence of the extension of the photographic method to this field; whilst cometary discovery has been quite as active as usual. In stellar astronomy Nova Aurigæ and the Variation of Latitude have indeed each in their several departments rather dwarfed other work; but Chandler's discussion of the period of Algol, pointing to the great probability of the existence of a second dark member of the system; the publication of the companion volume to the Draper catalogue, and of the Potsdam observations of the motions of 51 stars in the line of sight, are matters deserving prominent mention. The work of the photographic survey of the heavens has gone on steadily, whilst not a few very instructive photographs have been obtained of comets, planets, star groups, and nebulæ, apart from the routine work of the Survey.

The sun.

Sun-spots.—The striking increase in the solar activity which was the chief feature of the record of 1891 has continued to be manifest throughout 1892. The records for 1892 are, of course, far from complete at the time of writing this report, but so far as at present appears there was not a single instance of a day without spots. The quarterly reports of P. Tacchini (*Comptes Rendus*, cxiv. 156 and 973, and cxv. 218) show that a slight falling-off in the numbers of the groups of spots in December, 1891, was succeeded by a very marked revival in January. February was distinguished not only by the number of spots observed, but by the almost unprecedented dimensions of the largest. April, May, and June more than maintained the average of February as to the numbers

of spots, though no single spot appeared of dimensions at all approaching the great February outburst. Still, on the whole, the second quarter of 1892 was quite double that of the last quarter of 1891, either as regards the numbers or the areas of the spots displayed. July was even more strongly marked. **Miss Brown** (*Jour. Brit. Astr. Assoc.*, iii. 11) records that not only did several single spots of exceptional interest appear in this month, but also "two extensive trains, the first of which rivalled the great February group in longitudinal dimensions." This group "at its early appearance consisted of three large spots, but when on the wane became transformed into a multitude of smaller ones, closely connected together, almost like the links of a chain." The other great July group formed a striking succession of large spots somewhat more widely separated. The latter end of August and the early part of September were somewhat quieter, but there was a distinct revival towards the latter end of the month, and October showed several fine groups, one of which, though far less closely connected than the great February group, nearly rivalled it in its extreme dimensions.

But the outburst which marks the year is undoubtedly that of February. **E. W. Maunder** describes the principal spot as having, on February 13th, an extreme length of 14° of solar longitude, and a breadth of 8°·2 of solar latitude, equivalent to 92,000 and 62,000 English miles respectively, whilst the entire group of which it formed the principal part was nearly 25° in length, and 10° in breadth, or in miles 162,000 and 75,000. The area of the great spot on this day was 2,940 millions of square miles, or reckoning the smaller spots which clustered closely round it, the spotted area of the entire group was 3,530 millions of square miles. (*Knowledge*, xv. 68.)

Not only was the group interesting "as the largest ever photographed since the beginning of the Greenwich record" (Maunder, *Monthly Notices*, lii. 491), but its history presented some peculiar features. It was first seen, according to **E. W. Maunder**, on November 15th, 1891, and was not finally lost to sight until March 17th, 1892. It was thus watched throughout the whole of five semi-rotations, and though it only attained gigantic dimensions during the February appearance, it was a considerable group during all the other four appearances. The most remarkable feature in its history as a whole was the striking and persistent drift in latitude which it exhibited; its first appearance on November 15th being in S. lat. 16°·8, its final appearance on March 17th, in S. Lat. 28°·4. Small drifts in latitude are not unusual, but a drift so great in amount,

and so long-continued, is almost without precedent. (*Monthly Notices*, lii. 484.)

The record of the year, therefore, has quite borne out the anticipation which was expressed in the "Year-Book" for 1891 (p. 103), that the maximum would be an extremely active one, and as yet there has been no indication that the maximum has been passed; it is possible that we have not yet attained to it. If we follow the indications afforded by the distribution of the spots in latitude, it would appear that the summit of the curve is almost reached. For, as **P. Tacchini** has shown in his quarterly reports (*Comptes Rendus*, cxiv. 522 and 1,342; and cxv. 366), the great majority of the spots now lie in the zones, 10°—30°, with a distinct tendency towards the lower halves of those zones; whilst **J. S. Townsend** and others have called attention to the occasional appearance of small spots close to the equator. (*Jour. Brit. Astr. Assoc.*, ii. 449.) The mean latitude is distinctly lower than in 1891, though perhaps it has scarcely yet reached the point most typical of maximum.

In recent years the northern hemisphere has been the more prolific in spots up to maximum, the southern after maximum. In strict accordance with this habit, the northern hemisphere has been somewhat the richer during the past year, not for spots only, but also for faculæ and metallic eruptions. The tendency has, however, been towards equality between the two hemispheres, and prominences have been very evenly divided. A review therefore of the whole range of solar phenomena for the year tends to indicate that the actual point of maximum has been very nearly reached; whether it has been actually passed or not, it is yet premature to say; most probably it still lies before us.

Prominences.—The past year has not shown quite so marked an increase in chromospheric phenomena as in sun-spots. Still, the prominences have increased steadily, both as to number and average height and extent. The zones they have chiefly affected have been 40°—60° on both sides of the equator, though they have been found in every latitude except quite close to the poles. Some especially striking outbursts deserve mention. Thus, in connection with the great February sun-spot, **J. Fényi** observed a dazzling protuberance of a height of 124″ (50,000 miles) giving a *continuous* spectrum, whilst there was a series of metallic eruptions, many of them extremely bright at the same part of the limb. (*Comptes Rendus*, cxiv. 524.) This was just after the spot had disappeared at the west limb; before it reappeared again at the east limb **H. Deslandres**, on March 3, observed a prominence remarkable both for its brilliancy and its speed in the

line of sight, the greatest displacement of the lines corresponding to a motion of over 120 miles a second. Photographs of the spectrum of the prominence gave the entire series of 10 hydrogen lines, first discovered by Huggins in the ultra-violet spectra of the white stars. Other important lines were observed which had not been previously recognised in the chromosphere except on the occasion, mentioned above, of the prominence of Feb. 19. (*Comptes Rendus*, cxiv. 578.)

The month of April also was especially prolific in remarkable outbursts. Thus, **E. L. Trouvelot** observed an arched prominence on April 6, which extended along some 12° of the solar circumference; its length was thus more than 90,000 miles, whilst its height was but little short of 60,000. On April 8 the same observer recorded another which rose to a height of about 72,000 miles, increased in about half-an-hour later to more than 105,000. This eruption appeared to resemble a candle-flame in shape. On April 15, again, another great prominence was recorded, not so tall as the two just mentioned, but 34° or 255,000 miles in extent along the sun's limb. (*L'Astronomie*, xi. 249.) Three weeks later **J. Fényi** remarked an eruption distinguished by the great height which it attained, and the enormous rapidity with which the ascent was made. At 10h. 25m. Kalocsa M. T. the prominence was only a very small one, but at 12h. 11m. it began to show a very swift upward motion, and in 8m. time had reached a height of 140,000 miles, and it was still moving upward at a speed of 228 miles per second. The lower part of the prominence faded away, and the remainder appeared as a detached cloud, 160,000 miles from the limb, but still continued rising. The greatest height reached was 237,000 miles, the prominence fading away soon after. (*Mem. d. Soc. d. Spettr. Ital.*, xxi. 75.)

Prominence photography.—Very striking advances have been made in this field during 1892. **H. Deslandres**, working with a combination of instruments from which glass is excluded, a grating spectroscope provided with quartz lenses being used in connection with a siderostat and an 8-inch silvered speculum, has not only succeeded in photographing the entire Huggins series of the hydrogen lines in the spectrum of a prominence as stated above, but, in addition, has secured five lines more. As these agree closely in wave-length with the formula for the hydrogen spectrum given seven years ago by Balmer, and more recently confirmed by Ames, there can be no doubt but they belong to the same element. The same prominences also gave a number of bright lines in the ultra-violet belonging to aluminium,

magnesium, and iron, besides several lines the element producing which has not yet been determined. (*Comptes Rendus*, cxv. 222.) In the spectra of the faculæ Deslandres always finds the H and K lines doubly reversed; a discovery fully confirmed by G. E. Hale at the Kenwood Physical Observatory. The latter finds that these two lines are also doubly reversed in the penumbræ of spots, and that they always extend right across the umbræ, but in this latter region only as single lines.

G. E. Hale's principal work has been, however, the devising an instrument for photographing prominences and faculæ. The principle of the instrument lies in the employment, with a grating spectrum, of a second slit, so arranged in the focus of the viewing telescope that the K line of the fourth order always falls upon it. The photographic plate receives then only the K light, and by a suitable and simultaneous movement of the two slits the entire sun-spots—faculæ, chromosphere, and prominences—can be photographed at once, by monochromatic light. The fact, mentioned above, that the H and K lines are always bright in faculæ, causes these to be recorded on the photographs not merely near the limb of the sun, but even over the centre of the disk. Their extent and importance has come, therefore, into quite new prominence, and the curious result has been obtained of a group of spots being entirely hidden on the photographs by bright faculous masses which were wholly invisible to the eye. (*Astron. and Astro-Physics*, i. 603.)

The solar spectrum.—Apart from the above researches of Deslandres and Hale, there has been little to record as to work on the solar spectrum during the year. **F. McClean** brought out a beautiful series of "comparative photographic spectra of the sun and the metals," at the close of 1891. The metals illustrated were those of the platinum and iron-copper groups, and were 15 in number, the maps being arranged in six sections and extending from near D to above H. (*Monthly Notices*, lii. 22.) The important paper by **A. L. Cortie**, on the spectra of sun-spots observed by him in the B–D region during the years 1882—1889, has been published in the *Memoirs of the Royal Astronomical Society* (l. 29), but the preliminary abstracts were noticed in the "Year-Book" for 1891.

The rotation period of the sun.—**N. C. Dunér** has taken up the problem attempted some years ago by C. A. Young, and more recently by H. Crew, viz., the determination of the solar rotation period by the displacement of the lines in the spectra of the limbs. For this purpose Dunér chose a group of four lines, of which two were solar and two telluric. The motion of the limb

of the sun as it rotates on its axis causes, of course, a slight displacement of the solar lines, whilst the telluric are unaffected. The observations extended over three years, and ranged from the solar equator to Lat. 75°. They quite confirm the fact, which has been inferred from sun-spot observations, that the rotation period varies with latitude, but have much greater accuracy, and have been carried into far higher latitudes. They are not, however, decisive as to the true mathematical expression for the solar rotation. (*Recherchés sur la Rotation du Soleil*, *R. Soc. Sc. Upsala.*)

Sun-spots, magnetic storms, and auroræ.—The great February sun-spot having been accompanied by a violent magnetic storm and by brilliant auroræ, fresh attention has been drawn to the connection between the three orders of phenomena. **E. W. Maunder** pointed out (*Knowledge*, xv. 89) how strong was the evidence that the very largest sun-spots are answered by unusually violent magnetic storms, the great spots of 1882 being cited in connection with the February group as examples. **A. Ricco** found that of eleven magnetic storms in the early part of the present year all those of extraordinary violence, and nearly all those of considerable intensity, took place shortly after the passage of a great spot across the central meridian of the sun. (*Comptes Rendus*, cxv. 595.) This same law of "westerly position" is also brought out by examples which **A. J. S. Adams** brought together in a paper on the same subject. (*Jour. Brit. Astr. Assoc.*, ii. 343.)

The development of solar activity has been accompanied by a notable increase in the number of auroræ observed. **H. Corder** recorded 21 bright auroræ in the year ending Sept. 30, 1892, as against 12 in the preceding twelvemonth, and **Geelmuyden** states that the past winter was the most prolific in auroræ since 1871. (*Ibid.*, iv. 11.)

Temperature and thermal absorption of the sun.—**H. Le Chatelier** concludes that the sun has an *effective* temperature of 7,600° C., with an error probably not exceeding 1,000°. The actual temperature will no doubt be higher, as part of the solar radiations must be absorbed by its atmosphere. His experiments have been made with temperatures differing from one another by an amount four times greater than those of the most extended hitherto made, and he therefore considers them as capable of leading to more trustworthy conclusions. The effective temperature is defined as "that temperature which a body of emissive power equal to unity must have in order to send us radiations of the same intensity as those of the sun." (*Comptes Rendus*, cxiv 737.) An investigation bearing some relation to Le Chatelier's has been carried on at Potsdam by **E. B. Frost**, who has been

determining the decrease of the radiation of the sun's heat from the centre towards the limb, with results in fair agreement with theoretical values deduced from La Place's corrected formula in the "Mécanique Céleste," Book x. Observations of sun-spots made with the same apparatus give the radiation from the umbra of an average spot as about equal, area for area, with that of a district of the general surface $\frac{1}{10}$ of the radius from the limb. (*Astron. Nachr.*, cxxx. 129.)

The solar parallax.—Four stations were occupied during each of the transits of Venus in 1874 and 1882, with a view to making heliometer measures of the distance of Venus from the sun's limb, and **A. Auwers** has recently published the results of their reduction. From the 1874 transit the parallax obtained is $8''\cdot877 \pm 0''\cdot043$; from that of 1882, $8''\cdot879 \pm 0''\cdot037$. (*Astron. Nachr.*, cxxviii. 329.) A very different method, and with a very different result, has been employed by **H. Battermann**, who observed 250 occultations of stars by the moon in the 18 months from 1884, April, to 1885, October. He points out that the occultation of comparatively faint stars can be observed near new moon, and hence that the list of occultations predicted in our almanacs could be considerably and most usefully extended. The concluded solar parallax is $8''\cdot794 \pm 0''\cdot016$.

The moon.

In the department of lunar theory **F. Tisserand** has been giving attention to the hypothesis that tidal friction causes a retardation in the rotation of the earth, bringing about a gradual increase in the length of the day, and producing an apparent acceleration in the motion of the moon. But if this retardation really takes place, it must exert an influence on the apparent motions of other heavenly bodies, and Tisserand has therefore investigated the matter for the planet Mercury. Meeting, however, only with negative results, he concludes that the sidereal day has remained invariable, and that the effect of tidal friction on the rotation of the earth has been counteracted by the contraction of the earth due to cooling. (*Comptes Rendus*, cxiii. 667.)

A very considerable increase has been given during the year to our knowledge of the lunar surface by the beautiful photographs which have been taken with the great refractor of the Lick Observatory, and which have been subsequently placed in the hands of **L. Weinek** for examination and enlargement. A catalogue of new rills in Cleomedes, Einmart, Picard, and Longomontanus, is given by **E. S. Holden** in the *Pub. Astr. Soc. Pacific* (ii. 78), who also remarks in the same journal (ii. 116) that the Lick negatives "have brought out quite new features,

ruined craters 50 miles in diameter, long streaks and ridges, not suspected or even not perceptible in ordinary visual observation." A new craterlet near Billy, which is not on any of the classic maps, and the existence of which has since been confirmed by direct observation, was also discovered by Weinek on a Lick photograph. (*Astron. Nachr.*, cxxix. 305.)

W. H. Pickering at the superbly placed station of Arequipa, Peru, has given considerable attention to the systems of bright streaks observed on the moon, and suggests that they are probably composed of a light-coloured powder, possibly pumice, extending away from the craterlets. This hypothesis would explain why they are only conspicuous when the shadows visible on the moon are short. (*Astron. Nachr.*, cxxx. 225.) **E. S. Holden**, pointing out some apparent discrepancies between the position of these streaks on the Lick photographs and on the maps of the moon, suggests the possibility that they undergo a slight apparent shift of position as the illumination changes, and urges the desirability of the matter being properly investigated, offering at the same time to place the Lick photographs at the disposal of anyone wishful to take up the investigation. (*Pub. Astr. Soc. Pacific*, iv. 81.) **W. H. Pickering** has put the case very forcibly for the probability of there still being active volcanoes on the moon, and has called the attention of selenographic observers to the neighbourhood of Bessel, and the floor of Plato, as especially important regions in this connection. The evidence of real changes having taken place in Plato within recent years appears particularly strong. (*Observatory*, xv. 250.)

The Planets.

Venus.—An important memoir upon this planet has been published by **E. L. Trouvelot**, in which he gives the results of nearly twenty years' observations. Amongst the more important conclusions at which he arrives is that the old rotation period of De Vico is practically correct, and that though the precise time is not yet determined, it is not very far from 24 hours. The brilliant spots seen on the limb are permanent, and are very lofty mountains, which surround the poles, and rise above the dense and deep atmosphere of the planet. The equator is inclined only some 10° or 12° to the plane of the orbit, and the longitude of the ascending node is 2°. The irregularities so often detected at the extreme points of the terminator are real, and in Trouvelot's view are due to the great height of the polar mountains. The planet can be seen by the naked eye in full daylight whenever its distance from the sun is not less than 10° at inferior conjunction, or than 5° at superior. (*Observations sur les Planètes, Vénus*

et Mercure. Soc. Astron. de France, vi.) **Löschardt**, in a discussion of the observations made by Denning and others, and compared with his own, arrives at a similar conclusion with Trouvelot as to the rotation period of Venus, and finds no support of Schiaparelli's period of 224 days. (*Nature*, xlv. 210.) **J. J. Landerer** concludes from polarisation experiments that the visible surface of the planet consists chiefly of thick clouds, the light of Venus in crescent, at greatest elongation, not being polarised. This conclusion well accords with Trouvelot's observations, and explains the difficulty experienced in determining the period of rotation. (*Comptes Rendus*, cxiv. 1524.)

Mars.—Though the opposition of Mars which took place on August 4th was a very close one, and the planet had therefore a large diameter, the results of observations have been rather disappointing. For the planet was nearly at its greatest southern declination, and hence was peculiarly ill-placed with regard to northern observatories, whilst the weather was in general most unfavourable for work. Nevertheless, a number of interesting facts have been placed on record. A great number of Schiaparelli's "canals" have been re-detected by different observers; but their doubling or "gemination" has been only seldom seen. **C. A. Young**, observing under fine conditions with the 23-inch refractor at Princeton, found that markings which with low powers appeared to him to resemble the Schiaparellian canals, under higher magnification were resolved into "mere shadings, irregular, indefinite, and vague in outline, and often discontinuous." (*Astronomy and Astro-Physics*, i. 675.) The Lick observers, on the other hand, support the Italian astronomer, and not only recorded many of his "canals" as single objects, but, on August 17th, three of them independently observed the duplication of the Ganges, and **A. Stanley Williams**, an English observer of exceptionally keen sight, though armed with only a small telescope, has remarked the same change in the case of this and also of other of the canals.

But distinctly the most important contributions to areography have come, as might naturally have been expected, from Arequipa, where Mars was nearly in the zenith, and where the observer had the great advantage of an elevation of more than 8,000 feet. With these advantages **W. H. Pickering** has convinced himself that several very well developed "canals" cross the "oceans," a most important fact to remember in theorising on the meaning of the phenomena. The appearance or disappearance of some of the "canals" seems to be intimately connected with the seasons of the planet, and there are regions in the neighbourhood of the poles which appear green up to the vernal equinox, but

lose their tint almost immediately after. Pickering considers that two dark areas, under favourable circumstances, of a very distinct blue colour, are most probably water, and he found them present faint traces of radial polarisation when near the limb. As to the other so-called "oceans" and "canals," he is inclined to doubt if they contain water at all. (*Astronomy and Astro-Physics*, i. 668.) J. Perrotin, at Nice, has noticed a number of small white spots, not polar, which, when brought by the rotation of the planet up to the limb, evidently projected beyond it, indicating a height in some cases of over 40 miles; whilst several observers have remarked the curious phenomenon of a dark rift in the very centre of the white polar cap itself. The break-up and diminution of the polar cap as the planet approached opposition was very remarkable, and W. H. Pickering was much struck with the great and rapid changes in many of the leading details of the planet which followed upon it. *L'Astronomie* for June, 1892, and the following months, and *Astronomy and Astro-Physics* for the same period, contain a number of papers, illustrated by numerous drawings of the planet during the late opposition. A comparison of these, and especially of the drawings of W. W. Campbell, E. E. Barnard, W. Hussey, and C. A. Young, in the October number of the latter publication, show very forcibly how great is the difficulty in accurately representing the appearance of this planet. The accord of the different observers is just sufficient to show that they had the same chief objects under examination; the differences between them are much greater than can with any probability be assigned to real changes on the planet, and yet greater than could have been supposed would be caused by personality in seeing or in delineation. To make the problem more perplexing still, C. A. Young's drawing of the Kaiser Sea, whilst it differs considerably from the more recent drawings of the same district by several other observers, corresponds very closely to some of the best of the older drawings we possess, as those of Lockyer, 1862, of Dawes in 1864, and of Green in 1877.

Three writers have discussed the condition of Mars in a popular style. R. S. Ball, who gives great prominence to G. Johnstone Stoney's explanation of the absence of hydrogen from our atmosphere, and who insists on its probable absence from that of Mars (*Fort. Rev.*, Oct. 1892); E. W. Maunder (*Knowledge*, xv. 167), who argues for a rare atmosphere on Mars, and one usually tranquil, and largely free from dust; and E. S. Holden (*Forum*, xiv. 359), who inclines to the view that Mars may have a dense atmosphere, and be in a somewhat heated condition. The ideas which seem to have laid

hold of the popular imagination, that the "canals" are of artificial origin, that therefore Mars has inhabitants, and that it is possible for us to communicate with them, are too absurd for notice.

A most thorough and exhaustive monograph on the planet has also just been published by **C. Flammarion**, entitled "La Planète Mars." It contains more than 600 maps and drawings of the planet.

Jupiter.—The fading of the great red spot which has been so long the most prominent and familiar marking on the planet, has been the most striking event connected with the planet itself. There had indeed been a partial revival during 1891, but the process of fading, which had been so apparent in 1890, has continued through 1892. But the curious shoulder on the south edge of the South Equatorial belt still marks out the position of the spot, and is as conspicuous as ever. The rotation period of the spot, which had undergone a slight increase during 1891, became somewhat shorter again in 1892. Both the North and South Temperate Belts of the planet have presented features of interest; the former by the apparition of a series of strongly-marked dark spots of short rotation periods, and showing an equatorial drift, and the latter by the formation of a long dark marking which at one time was of an intensely reddish-brown tint. Later it faded almost entirely away, and it survives only as a comparatively feeble marking. Its rotation period has been a little irregular, but it has tended to; ain on the red spot. The Equatorial Zone has been less active than usual, the most noteworthy circumstance concerning it being the coming into somewhat greater distinctness of a faint belt, almost precisely on the planet's equator. (**W. R. Waugh**, *Jour. Brit. Astr. Assoc.*, iii. 14.)

Photography as applied to Jupiter has made very distinct advances, some very beautiful negatives having been secured by **A. A. Common** (*Monthly Notices*, lii. 18) and at the Lick Observatory. Several of the latter have been presented to the Royal Astronomical Society, and a number of these have been measured by **A. S. Williams**, who reports that "the photograph evidently compares favourably with the *average drawing* of Jupiter, in point of quantity of detail, and is certainly immensely more accurate; though of course we can see visually much more minute details than can be photographed at present." (*Pub. Astr. Soc. Pacific*, iv. 166.)

Satellites of Jupiter.—The most striking discovery of the year has been the detection of a fifth, or rather an inner, satellite of Jupiter. **E. E. Barnard** had devoted such opportunities as were open to him for searching with the 36-inch refractor for other

satellites of Jupiter, and on September 9th detected an exceedingly faint star, close to the third satellite. A series of measures made on the following evening, and repeated on the next few nights, showed beyond all doubt that it was really a new satellite, and determined its distance to be about 112,400 miles from the centre of Jupiter, and its period of revolution about 11h. 57m. The orbit of the new satellite lies in the plane of the planet's equator. Its brightness is estimated to be about equal to that of a star of the 13th magnitude, though its close proximity to the planet renders observation especially difficult, and Barnard regards it as a far more difficult object than either of the satellites of Mars. (*Astron. Journ.*, xii. 81.) It has since been observed by **T. Reed**, with the 23-inch refractor of the Halstead Observatory. He does not consider it a specially difficult object under favourable circumstances, and considers that it should be looked for with telescopes even of 15 or 20 inches. (*English Mechanic*, lvi. 294.)

The great Lick telescope has also been employed for the determination of the rotation period of Ganymede, the third satellite, and both **J. W. Schaeberle** and **W. W. Campbell** succeeded in detecting a number of markings upon it. The observations render it exceedingly probable that the satellite, like our own moon, always turns the same face to its primary. (*Pub. Astr. Soc. Pacific*, iii. 359.)

A. A. Michelson has employed the method of interference in order to measure the diameters of the satellites of Jupiter, with the following results:—I., 1″·02; II., 0″·94; III., 1″·37; IV., 1″·31. The diameter thus obtained for the third satellite is much smaller than that arrived at by other observers, **Hough and Burnham**, for example, giving it as 1″·78; but for the three other satellites, and especially for the first two, the agreement with the micrometrical method is quite close. (*Nature*, xlv. 160.) Probably the third satellite has a higher albedo, or coefficient of reflection, than the others.

Saturn.—The disappearance of the rings during October, 1891, in consequence of the passage of the plane of the rings through the sun, was all but repeated on May 20, 1892, when they nearly disappeared a second time, due to the earth coming nearly into the plane of the rings. The date fixed by **A. Freeman** for the reappearance of the ring, 6 o'clock on the morning of Nov. 1 (*Jour. Brit. Astr. Assoc.*, ii. 68, and "Year-Book" for 1891, 109), proved to be a little late, **E. E. Barnard**, with the superior opportunities and powerful equipment of the Lick Observatory, ascertaining that the time fell between 9h. 3m. and 17h. 0m. on October 29, 1891, Mount Hamilton Mean Time. (*Monthly*

Notices, lii. 419.) Another interesting phase was presented by the planet on March 12, 1892, when the elevation of the sun and of the earth above the ring was the same, 2° 3′. As the planet was near opposition, the particles of the crape ring hid their own shadows. **A. Freeman**, observing the planet on this occasion, convinced himself that there was a pale red band apparently almost in contact with the crape ring, but which was a true north equatorial mottled red belt having its S. edge on the true equator of Saturn. From the fact that between the crape ring and this belt a portion of the bright surface of Saturn was visible, Freeman argues that if any atmosphere is attached to the rings it lies over the crape ring only. (*Jour. Brit. Astr. Assoc.*, ii. 272.)

The position of the planet has been very favourable for observing transits of the satellites across the disk, and on March 11, **A. Freeman** observed a dark transit of Titan, and of his shadow. Transits of the shadows of Rhea, Enceladus, and Mimas have also been observed.

Search for a planet beyond Neptune.—**I. Roberts** instituted a photographic search for a planet beyond Neptune in accordance with the predictions of **G. Forbes**, and two sets of negatives at an interval of not less than seven days were taken of the region the latter had indicated. The plates were then carefully compared by superposition, but no trace of a new planet was discovered, although no object of the 15th magnitude or brighter could well have been overlooked. (*Monthly Notices*, lii. 501.)

Albedoes of the planets.—**O. Lohse** has published during the year the observations which he made of the planet Mars during the oppositions of 1884–6–8. These include a series of observations made during October, 1883, of the comparative photographic brightnesses of Jupiter and Mars. The superiority of the former planet was most remarkable, the albedo of the southern hemisphere of Jupiter for the actinic rays being 24·4 times that of Mars. That of the northern hemisphere was considerably lower, being almost exactly half the amount, or 12·1. (*Pub. des Astroph. Obs. zu Potsdam*, viii.) **J. E. Gore** has compared the albedoes of the various planets for the visual rays, and finds Uranus to come first with an albedo of 0·68, whilst Mercury, with an albedo of 0·13, comes even lower than the moon, 0·17. (*Knowledge.*)

Minor Planets.—The discovery of new minor planets has gone on with great rapidity during the year, the number having been raised from 322 to 380, owing to the employment of photography for their detection. No fewer than twenty have been discovered by this means, in one instance four minor planets, of which two were previously unknown, being registered on a single plate. In

consequence of the confusion introduced in the numeration of the asteroids by the rapidity with which new discoveries sometimes followed each other, **A. Krueger** has suggested that asteroids should, like comets, be designated on their discovery simply by a letter in conjunction with the year. Later, when the discovery has been fully verified and the orbit determined, a place in the general catalogue of asteroids can be assigned to it. (*Astr. Nachr.*, cxxx. 160.)

Comets.

Several important comets have been discovered during 1892, the first being one detected by **L. Swift** just before daylight on March 7. It was then 30° south of the equator in Sagittarius, and was bright enough to be seen with the naked eye on the following evening. It moved somewhat rapidly in a north-eastern direction, and so soon became favourably situated for European observatories. On April 4 it had a tail 20° long, as observed at the Lick Observatory. Photographs taken at that observatory by **E. E. Barnard**, and by **H. C. Russell** at Sydney, showed a large amount of detail, the knots and bends in the tail, and the apparent darkening of the sky about the head of the comet, being the principal features. (*Knowledge*, xv. 229.)

Eleven days later two comets were discovered, one a small faint object detected by **W. F. Denning**; the other, the Pons-Winnecke comet of 1819 and 1858, being redetected by **R. Spitaler.**

The fourth comet of 1892 was discovered by **W. R. Brooks** on August 28. It became well observed later, as it brightened a good deal and developed a considerable tail.

Photography, which has proved so powerful an agent for the detection of new asteroids, secured the fifth comet, which was discovered on October 12 by **E. E. Barnard.** If an exception be made of the comet discovered during the total solar eclipse of 1882, this is the first occasion on which a comet has been detected in this manner. **M. Schulhof** concludes that its orbit is very similar to that of Wolf's periodic comet of 1884 and 1891. He suggests that the two were originally one, but were separated in 1875 by the action of Jupiter.

The sixth comet was discovered by **E. Holmes** on November 6. It was believed at first to show an orbit very similar to Biela's, but later observations corrected this impression, and it was soon seen that elliptic elements would satisfy the observations. **A. Berberich**, amongst others, found that it was a short-period comet—Berberich's period being 6·78 years, nearly the same as that of Wolf's comet, alluded to above. This would point to its having been captured by Jupiter. The orbit appears to lie wholly

between those of Jupiter and Mars. (*Edinburgh Circular*, No. 35.) A record of the comet appears to have been obtained in a photograph by **W. Schooling** of the region of the Andromeda nebula, on Oct. 18, and **E. Roberts** found that by accepting the place given by this photograph he derived an orbit with a period of fifteen years. (*Monthly Notices*, liii. 66.) A remarkable circumstance about the comet has been the way in which it has increased in angular diameter whilst receding rapidly from the earth. It has become more and more diffused at the same time, and therefore more difficult to observe.

The seventh comet was discovered by **W. R. Brooks** on November 20. It was circular in appearance, about 1′ in diameter, fairly bright, but showing no tail.

Nova Aurigæ.

It should be a great encouragement to the amateur observer possessed of but small optical means that while one of the two great discoveries of the year, that of the fifth satellite of Jupiter, fell to the largest existing refractor, the other was secured by means of a common half-guinea spy-glass. **T. Anderson**, during the last week of January, remarked an unfamiliar star near 26 Aurigæ, and drew the attention of the Astronomer Royal for Scotland to it on February 1. The next evening its spectrum was examined by **W. Huggins** at Tulse Hill, and its place determined at Greenwich. On February 3 its spectrum was photographed both at Stonyhurst and at South Kensington, the first of a most important series of photographs obtained at different observatories, which place this Nova far above all previous Novæ as to the information which it has afforded us.

The first point about the Nova was that it had gained its brightness several weeks before it was discovered, for a comparison of photographs of the region taken by **E. C. Pickering** at Harvard College, and by **Max Wolf** at Heidelberg, shows that it had suddenly risen from fainter than the 8th magnitude to brighter than the 5th between December 8, 1891, and December 10.

The Nova proved very unstable in its brightness. After varying one way or the other for about a month, its light began to fade about March 6, and it decreased steadily and with great rapidity, until by the end of May it had sunk to the 15th magnitude. It was then entirely lost for a time, but on August 19 **H. Corder** found it had revived again, and was brighter than the 10th magnitude, only to fade again shortly afterwards. **E. E. Barnard** also observed it about the same time, but remarked that the star had now the appearance of a planetary nebula, some 3″ in diameter.

Its spectrum, both visual and photographic, was exceedingly complicated. The most conspicuous characteristic was the presence of a number of bright lines, amongst which those of hydrogen were prominent. Side by side with these lines was a similar series of dark lines, so that the star showed a double spectrum, one of radiation, and one of absorption, but the two spectra were displaced with regard to each other. If this relative displacement be explained by what appears to be the most natural and indeed inevitable suggestion, we are compelled to conclude that the source of the bright line spectrum was receding from us in the line of sight, as compared with the source of the absorption spectrum, at a speed of more than 500 miles per second. Further, many of the dark lines appeared divided, and the bright lines likewise showed two or three maxima, as if we were dealing, not with two bodies moving in different directions, but with several moving with every variety of speed. **H. C. Vogel** considered that the spectrum of the Nova consisted of at least three spectra superposed, their respective motions in the line of sight with regard to the earth being in one case 400, in a second case 23 miles per second of approach, whilst the third was receding with a speed of 300 miles per second. (*Astr. Nachr.*, cxxix. 109.)

The difficulty of explaining motions so rapid and continued so long is very great. **W. Huggins** supposes that two gaseous bodies moving with hyperbolic velocity passed extremely near to each other, causing enormous tidal disturbances which produced eruptions similar to those we witness on the sun, but on a far greater scale. The division of the bright and dark lines into two or even three parts would then be explained as "reversal" lines, such as are often witnessed on the sun, when portions of the same gas at different temperatures overlap each other. (*Fortnightly Review*, June, 1892.)

Agnes Clerke explains the observations by supposing that Nova Aurigæ was really composed of two bodies, the principal of which was a "white" star like Rigel. Such bodies she considers to be in "a state of powerful electrical excitement, creating in its neighbourhood a very extensive magnetic field. A second body entering this field, and sweeping with prodigious speed across the lines of forces traversing it, must then give rise to powerful electrical agitations." (*Contemporary Review*, April, 1892.) **W. Sidgreaves** considers the evidence points to a tremendous chromospheric disturbance in a single star; whilst **H. Seeliger** prefers the idea of a star becoming involved in a cosmical cloud. (*Astr. Nachr.*, cxxx. 393.)

The hydrogen lines from C in the red, up to the entire Huggins "white star" series in the ultra-violet, though the most obvious, were far from being the only bright lines observed. **W. Huggins** identified sodium, but found a complete absence of correspondence to the typical cometary spectrum, viz., that of the hydrocarbon flame. The nebular lines were also wanting, though a strong line was found near the place of the chief nebular line. (*Astr. and Astro-Physics*, i. 571.) The presence of magnesium was considered doubtful. But **W. Sidgreaves** identified several of the leading chromospheric lines, and **W. Huggins** found a set of bright lines far beyond the end of the hydrogen series in the ultra-violet, a significant testimony to the enormous temperature to which the star had been raised. **R. Copeland** traced a correspondence between some of the bright lines of the Nova, and those he had observed in the spectra of R. Andromedæ and R. Cygni (*Ibid.*, 593), and **J. N. Lockyer** found probable coincidences with the Wolf-Rayet stars, with the dark lines in the Orion stars, and the bright lines in the Orion nebula. (*Proc. Roy. Soc.*, l. 431.) **W. W. Campbell** gave a long list of identifications, including many chromospheric (mostly iron) lines, and several lines of magnesium, calcium, iron, sodium, and cerium. (*Astr. and Astro-Physics*, i. 820.) The Nova at its revival in September and October gave a simple and possibly a nebular spectrum (*Ibid.*, 820), thus furnishing another instance of connection between a "temporary" star and a nebula.

Sidereal astronomy.

Algol.—It was stated in the "Year-Book" for 1891 (p. 113) that H. C. Vogel had established, by means of his spectroscopic observations, that the variation in the brightness of this star was due to a partial eclipse, a dark companion coming between the earth and Algol in its revolution round the latter. But the period of Algol was already known to be subject to certain systematic irregularities, which seemed somewhat at variance with this theory. **S. C. Chandler**, however, after having first carefully determined the law of these variations in the period, has worked out a theory in explanation of them, and he ascribes them to the varying distance of the Algol system from the earth, and the consequent changes in the time taken by the light of Algol in travelling to us. In other words, Algol and its satellite revolve round a third body, like the satellite, a dark one, in an orbit of the same dimensions as that of Uranus round the sun, but in a period of 131 years. The maximum retardation or acceleration of the eclipses should be 149 minutes, the orbit being supposed circular and inclined at an angle of 20° to the line of sight. In reality,

however, the retardation amounted to no less than 165 minutes in 1843, so that there are still further outstanding irregularities of which account must be taken. These are referred by Dr. Chandler to a disturbance of the proper motion of Algol, the meridian observations in his view indicating that the star is moving in an ellipse with a major axis of 2″·7. This conclusion would involve that the system is distant from us 15 million times as far as the sun, so that its parallax would be 0″·07, and Algol would have about the same actual brightness as Sirius. (*Astron. Jour.*, xi. 113.)

The other variables of the Algol type, like their prototype, are supposed to owe their variation to a partial eclipse by a dark satellite. Several of them, Υ Cygni especially, show, like Algol, irregularities in their periods, pointing to a similarly complicated system. But these are not the only indications of the existence of "dark suns." The triple star, ζ Cancri, has been shown by H. Seeliger to give evidence by the looped path of star C of the presence of an unseen fourth member of the system, and **S. W. Burnham** (*Monthly Notices*, li. 388) points out that such irregularities of motion are common amongst double stars, though, apparently forgetful of the evidence of the Algol type stars, he shrinks from adopting the hypothesis of invisible disturbing bodies.

The variation of latitude.—Another investigation of an even more important character than this on the period of Algol, and far more laborious, has also been carried out by **S. C. Chandler.** On the assumption that the earth is a perfectly rigid body, it has been shown that the axis of rotation would not be coincident with the axis of figure, but would itself revolve round it in a period of 306 days, causing thereby a slight apparent change in terrestrial latitudes. This change was from the length of the period commonly known as the "ten-month variation of latitude." Several astronomers, amongst whom may be mentioned Peters, Nyrèn, and Newcomb, have attempted from time to time to determine from observation the amount of this variation; but the declinations of stars, as determined at different observatories, failed to give any definite and coherent result, and it was supposed that the amount of the shift was so small that we were not able to measure it with our present means. Professor Chandler, however, from the discussion of some 33,000 observations, has found strong evidence that the change takes place in 427 days, or about fourteen months, and not in ten, as had been supposed; and **S. Newcomb** concludes, from a very careful consideration of the whole question, that this period is not at all inconsistent with the requirements of theory. For if we abandon

the assumption of a rigid globe, adopted only for simplicity, and make a perfectly plausible assumption as to the elasticity of the earth, taking it to be about as great as that which Lord Kelvin concludes is demanded by the phenomena of the tides, the fourteen-month period can be accounted for.

Prof. Chandler has not only fixed the period of the variation, but the amount; and his conclusion is that the axis of rotation revolves round the axis of figure in the direction west to east, and at a distance of 25 feet. As this conclusion rests upon observations which are not only very numerous, but which have been made at seventeen observatories, of which four were south of the equator, and with twenty-one distinct instruments, and by nine different methods of observation, the evidence in its favour is very weighty. (*Astron. Jour.*, Nos. 248–273 inclusive.)

It may be noted that in one important matter Profs. Chandler and Newcomb are not agreed—the former considering that the amplitude of the variation has been constant, but that the earlier observations show that the period was formerly shorter. Newcomb, on the other hand, concludes that both period and amplitude are subject to perturbations. The observations which Chandler has treated do not appear to give any evidence of secular change of latitude.

Stellar photography.—The chart of the heavens has made good progress during 1892, a most important decision having been arrived at with regard to the length of exposure of the plates. A great number of experiments were made with screens placed before the object-glass, so as to shut off $\frac{5}{6}$ths of the light, in order to determine the correct exposure to secure a distinct image of an 11th magnitude star. These experiments were, however, not found to be successful for the purpose intended, the resulting images showing diffraction effects and other modifications. The screens have therefore been laid aside, and a slight modification of the procedure decided upon at the Conference of Easter, 1891 ("Year-Book" for 1891, p. 115), has been adopted. The full exposure for the catalogue plates has been adopted as six minutes; this is to secure good measurable images of 11th magnitude stars. A second exposure of three minutes is given so that accidental specks may be differentiated from real stars. And a third of twenty seconds, recommended by **W. H. M. Christie**, will give a series of stars down to about the 9th magnitude, which will serve for comparison with the charts of the Bonn Durchmusterung, which embraces stars of that order, and so will afford an indication as to whether any special circumstances have prevented the 11th magnitude stars from being recorded by the longer exposure.

M. Loewy has also made a very important contribution to the success of the scheme by devising a method for greatly diminishing the number of standard stars to be observed with the transit circle. He has elaborated a method of connecting the measures of the stars on contiguous plates, so that very much fewer than the 60,000 or 70,000 standard stars, required according to the original scheme, will suffice. (*Bulletin der Comité International Permanent*, Tome ii., fasc. 1.)

The actual work of the Survey is being pushed on rapidly. Thus, at Greenwich about 700 plates have been already secured, and some of the foreign observatories are yet further advanced. Political occurrences have hindered the readiness of the South American observatories, but with their exception the real work of the Survey is being pushed on smoothly and rapidly.

In general stellar photography there has been little to note beyond some fine plates of the Eta Argûs nebula by **H. C. Russell**, some of which show from 3,500 to 4,500 stars to a square degree in the denser parts of the nebula; a survey of the region of Nova Cygni (1876) by **Isaac Roberts**, from which several changes during the last sixteen years are inferred; photographs of the Crab nebula in Taurus, by the same observer; and a survey of the greater part of the constellation Cygnus by **Max Wolf**, which shows some very interesting structures in the Milky Way. **E. C. Pickering's** automatic recorder, a photographic telescope so mounted and driven that it secures a record automatically of the entire sky during a night, registering stars down to the fifth or six magnitude, deserves a special mention, as it is by the registers thus obtained that we are able to ascertain when Nova Aurigæ first flashed up into brightness.

A valuable contribution to the mensuration of the Pleiades has been made by **H. Jacoby**, who has measured and reduced the photographs taken by L. M. Rutherford in 1872 and 1874 with his 13-inch telescope. These beautiful plates, containing twenty exposures on the group, have proved susceptible of very accurate measurement, the probable error of the mean places deduced being only about $0''{\cdot}03$ in each element. (*New York Acad. of Science*, vi. 239.)

The Milky Way.—A beautiful series of drawings of the Milky Way, made by **Otto Boeddicker**, have been published during the year. The drawings, which were made without optical assistance, employed Dr. Boeddicker nearly five years of hard work, and display an amazing amount of delicate detail.

Double stars.—Three important memoirs on double stars have appeared during the year: Asaph Hall's observations with the

26-inch equatorial of the Washington Observatory, made during the period 1880–91 (*Washington Observations*, 1888, App. i.); **S. W. Burnham's** measures with the Lick telescope, embracing many most difficult objects, some of which had not been measured since the time of their discovery (*Astron. Nachr.*, cxxx. 257); and **W. H. Maw's**, made with a 6-inch telescope at Kensington (*Mem. R.A.S.*, vol. l.)

The system of Sirius.—The irregularity in the proper motion of this star had occasioned the existence of a companion to be suspected long before its discovery by Alvan Clark in 1862. **Auwers** had then already begun a careful discussion of the observed positions of Sirius, which he published in 1868. He has now collected and discussed all the observations of the companion of Sirius from 1862 up to 1890, and deduced an orbit which not only satisfies the measures of the companion, but agrees in a very satisfactory manner with the meridian observations of Sirius. Adopting Gill and Elkin's value for the parallax of the star, the masses of Sirius and the companion are respectively 2·20 and 1·04 times that of the sun, the mean distance apart of the stars is about equal to that of Uranus from the sun, and the period is 49·4 years. (*Astr. Nachr.*, cxxix. 185.)

Motions of stars in the line of sight.—**H. C. Vogel** has published his first volume of results of his observations of motions of stars in the line of sight obtained by means of photography. His results show a very great advance in their general accordance upon those obtained by the visual method at Greenwich or elsewhere, and abundantly demonstrate the great advantages which photography possesses for this class of work. Some fifty-one stars have been observed, and the rates of motion obtained have been considerably lower than those obtained by W. Huggins, E. W. Maunder, and G. M. Seabroke. (*Potsdam Observations*, vii.)

A fair proportion of stars observed both at Tulse Hill (Huggins) and at Potsdam agree as to direction; a larger proportion of stars observed both at Greenwich and Potsdam agree, and a strong presumption is created that orbital motion is the cause of many of the apparent discordances, by the fact, pointed out by **E. W. Maunder** (*Observatory*, xiii. 393), that the Greenwich results, intermediate in time between those of Huggins and Vogel, tend to be intermediate also as to the motion recorded. The Potsdam results appear to point to but a very moderate speed for the sun in its progress through space.

Deslandres at Paris, and **W. W. Campbell** at Lick, have also made some experiments in the same field; so far, with results confirming the Potsdam observations.

The motion of the solar system.—**G. Porter** has made a fresh attempt to solve the problem of the sun's motion in space. Following Dr. Stumpe's method, he has divided the 1,340 stars with which he has dealt into four classes according to the amount of their proper motions, and finds the apex of the "sun's way" not far from the constellation Lyra, the stars with smallest proper motion placing the apex the furthest north, in Draco, and those with the greatest proper motion a little south of Vega. The "line of sight" observations of Vogel appear also to point to the neighbourhood of Vega as the point towards which the solar system is at present directing its way. (*Cincinnati Obs.*, No. 12.)

Stellar parallax.—Prof. Porter, like Dr. Stumpe, concludes that the proper motion of a star is an index of its distance from us. **C. Pritchard**, whose "Researches in Stellar Parallax by the Aid of Photography" have just appeared, and have won for him the Royal Medal of the Royal Society, appears to hesitate to make such an assertion. The result of a comparison between proper motion and parallax in those cases where the latter has been well determined, shows no universal and intimate connection between large motion and parallax. So, too, with stellar magnitude and parallax. Though the apparent brightness of a star, just as its apparent rate of motion, must be affected directly by its distance, yet it is quite clear that all the brighter stars are not the nearest to us, nor all the fainter the furthest from us. Still, just as Gill and Elkin deduced 0″·089 as the average parallax for stars of the first magnitude, so Pritchard finds 0″·056 for the average parallax of the second—it being borne in mind that in both classes the parallaxes obtained for the individual stars examined varies from nothing to half a second of arc. All that can be said is that the fainter stars show, on the whole, a slightly increased tendency to yield a smaller parallax.

METEOROLOGY.

By CHARLES HARDING, F.R. Met. Soc.

The synchronous system of charting observations, now commonly employed by the Weather Offices of our own and other Governments, is enabling a satisfactory explanation to be given where before all was mystery, and it is probably by the aid of synchronous and synoptic charts, embracing a large area of the earth's surface, that our knowledge of the laws which govern the weather will be extended. Good work has been performed during the

year in the way of perfecting anemometrical records, and by the introduction of improved instruments for the measurement of wind velocity and pressure. The record of bright sunshine is also becoming more general, and is now a feature of almost every meteorological station. The stage of the science at present is that materials are being collected in large quantities, and there is much need for some master-builder to construct his theories.

Atmospheric circulation and barometrical disturbances.

James Thomson delivered the Bakerian Lecture on the grand currents of atmospheric circulation. After giving a historical sketch of the progress of observational and theoretical researches into the nature and causes of the Trade Winds and other great and persistent currents of atmospheric circulation, the author propounds the theory that at the equator, or near to it, there is a belt of air ascending because of its high temperature and consequent rarefaction; that its supply of air is maintained by influx from both sides towards the zonal region at its base, which is a region of diminished pressure; that from its upper part currents float away to both sides northward and southward; and that these currents continue in the upper regions of the atmosphere, each of them advancing towards, and in part to, the high latitudes of its own hemisphere, until, by cooling, its substance becomes less buoyant and sinks down gradually in various latitudes of that hemisphere, and forms itself into a return current towards the equator in the lower part of the atmosphere. Prof. Thomson explained that over the middle, or middle and higher latitudes, there are three currents:—

(1) A top main current towards the pole.

(2) A bottom subordinate current towards the pole.

(3) A middle main current in direction from the pole, and constituting the joint return current for both the preceding currents; and that all these three have a prevailing motion from west to east, in advance of the earth. That the great return current, flowing in direction from the pole towards the equator, arrives at a certain part of its course at which it ceases to revolve eastward in advance of the earth; and for the rest of its course to the foot of the equatorial rising belt, it blows along the surface of the earth as the trade wind of the hemisphere in which it is situated. (*Proc. Roy. Soc.*, li. 42.)

R. H. Scott, lecturing on "Atlantic Weather and its Connection with British Weather," explains the broad principles which govern the weather system of the Atlantic. The author describes some of the results brought out by a discussion of the daily

synchronous charts of the North Atlantic for the 13 months ending August, 1883, which have been published by the Meteorological Office. It appears that there were 273 depressions during the 13 months, whose tracks were clearly traceable. By omitting those which appeared in August, 1882, the number is reduced to 264, which lasted as follows :—

Duration in days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of Depressions	36	33	40	31	27	23	22	14	7	13	6	3	3	2	—	1	1	1	—	1

Of these, 140 lasted less than 5 days. Those of longest duration were confined entirely to the autumn months. During the 13 months there were 37 severe gales felt on the coasts of the British Islands, which were classified as follows :—

Appearing westward of Long. 40°	17
„ in Mid-Atlantic	8
Formed close to the British Isles	9
Appearing to the eastward	3

Of the 17 cases given above as starting near the American coast, only 12 came within the area of observation on the other side of the Atlantic. For the 12 storms, the times taken to cross the Atlantic were :—

4	storms	took	2	days.
3	„	„	3	„
1	„	„	4	„
1	„	„	5	„
2	„	„	6	„
1	„	„	10	„

The author is of opinion that storm warnings from America are not of much service to this country. (*Jour. R. U. Service Inst.*, xxxvi. 499.)

Henry F. Blanford discusses the winter storms of Northern India. It is pointed out that the storms of India differ very greatly in their leading characteristics at different seasons of the year. There are the well-known cyclones and cyclonic storms of the Bay of Bengal and the Arabian Sea, which are most frequent when the summer monsoon is at its height, and most severe at its commencement and termination. The storms that bring the rainfall of the cold season and the earlier spring months to Northern India are of a very different type. These storms, if they travel, always move from west to east. They have the usual cyclonic constitution, but the winds have but little force; and it was not until the preparation of daily weather charts for the first time showed their true nature, that this fact was even suspected. Each of these cold-weather storms is preceded by a wave of high

temperature, and followed by a cold wave, except when the course of the storm is so far south of the Himalayas that little or no snow falls on the mountains. The author remarks on the general resemblance of the winter storms of Northern India to those of our own latitudes. In their eastward movements, the localisation of the rainfall, the contrasted temperature conditions of the opposite quadrants, and many other particulars, we may recognise their essential identity. But certain features which are more or less blurred in our European storms stand out in the case of the Indian storms with much clearer definition; and they seem calculated to throw not a little light on the still vexed question of storm generation, and perhaps to reconcile some of the very conflicting views that now prevail on this subject. (*Nature*, xlv. 490.)

W. L. Dallas writes on "The Appearance and Progressive Motion of Cyclones in the Indian Ocean." He remarks that the common assumption is that a cyclonic system arises from the unequal distribution of temperature over and above the earth's surface. Given a more or less circular area of abnormal heat, it is held that interchanging motions between the exterior and interior parts of the system will arise. It is also held that this interchanging motion, owing to the deflecting force of the earth's rotation, will take the form of gyrations around the centre of abnormal temperature, and that from such a system a cyclone will arise. With regard to the controlling influence on the progressive motion of cyclones, all available evidence seems to show that this is centred in the movements of the upper atmosphere. The average curves which the cyclones of the Indian region, of the Gulf of Mexico, and of the Pacific Ocean, describe, are so obviously similar to the curves which the upper currents of the atmosphere describe in their passage from the equator to the temperate zones, that they form strong presumptive evidence that the relation between the two is that of cause and effect. (*Amer. Met. Jour.*, ix. 112.)

A. Woeikof deals with the subject of "Cold Waves." He says there are two reasons why, in winter, high mountains should be colder than the free air at the same level and under otherwise similar circumstances. (1) In calm, clear weather the surface of snow cools intensely, and this cold is communicated to the lower stratum of air. The larger the surface of the summit, the more important is this. (2) In windy weather, when the wind comes from colder regions, the air ascends along the slope of the mountain, and is cooled by about 1°·6 Fah. for 300 feet, that is much more than the mean rate of increase of temperature.

These two causes of cold do not exist in free air. Cold waves are not unknown on the old continent. They are exceedingly rare in the extreme west, and more and more frequent and strong as we advance towards the plains of Western Siberia and Turkestan. Yet even there they are not so frequent as in the United States. (*Amer. Met. Jour.*, viii. 376.)

J. M. Pernter delivered a lecture before the Scientific Club in Vienna, on "The General Circulation of the Atmosphere." The author deals with the history of the subject, and traces the different theories of Dove, Buys Ballot, Ferrel, and others. He states that in consequence of the unequal heating of the sun and of the rotation of the earth, air currents occur at all parts of the globe. These currents are easterly between 35° N. and 35° S. latitude, and westerly outside this zone. ("Translation of Lecture," *Nature*, xlv. 593.)

Thunderstorms, etc.

A. B. M. discusses the relation existing between thunderstorms and sun-spots. He deals with observations for Berlin from 1850 and for Geneva from 1852; these show a decided agreement between the maxima of thunderstorms and minima of sun-spots, and similarly with minima of thunderstorms and maxima of sun-spots. There is not always exact coincidence, but a very considerable correspondence will be noticed. A table is also given which shows the number of days on which thunder was observed during the six months, April to September in each year, from 1850 to 1891. These observations seem to show an agreement between maxima occurrences of thunder and minima sun-spots. (*Nature*, xlvi. 488.)

J. P. van der Stok, in discussing the observations made at the Magnetical and Meteorological Observatory, Batavia, for the years 1866–90, considers it proved beyond doubt that at Batavia the moon has an appreciable influence on the number of thunderstorms. The cloud-curve also shows an increase of cloudiness as the moon rises above the horizon. After the moon has set, the cloudiness does not decrease at a continuous rate, but apparently remains constant.

W. von Bezold contributes a memoir to the Berlin Academy on "Thermodynamics of the Atmosphere." The author considers the cases of supersaturation with vapour and of overcooling. A sudden cessation of these states, he shows, must result in rapid rise of air-pressure, which is generally of short duration, unless conditions are present which prevent its descent again. These variations of pressure are said to be characteristic of thunderstorms, and the movements and changes in form of

thunderclouds, and the origin of hail and other phenomena, are associated with super-saturation and over-coolings. The opinion is expressed that much thunderstorm rain has, high up, the form of hail or sleet, and the large drops are simply melted hail or sleet particles, these forms playing a more important part in thunderstorms than is commonly supposed.

Temperature.

William Ellis has discussed the mean temperature of the air on each day of the year at the Royal Observatory, Greenwich, on the average of the fifty years, 1841 to 1890. The values used in the discussion are derived from eye observations from 1841 to 1848, and from the photographic records from 1849 to 1890. The mean annual temperature is 49·5°. The lowest winter temperature, 37·2°, occurs on January 12, and the highest summer temperature, 63·8°, on July 15. The average temperature of the year is reached in spring on May 2, and in autumn on October 18. The interval during which the temperature is above the average is 169 days, the interval during which it is below the average being 196 days. (*Quart. Jour. Met. Soc.*, xviii. 237.)

M. Angot, at the meeting of the French Meteorological Society in December, 1891, gave some results of the temperature observations made during the year 1890 on the Eiffel Tower at 515 feet, 646 feet, and 990 feet above the ground. At night the temperature increases up to a mean height of about 500 feet, then decreases, slowly at first, and afterwards more rapidly; at about 1,000 feet the mean decrease of temperature is 1·4° for each 100 metres or 328 feet. During the day the temperature decreases constantly from the ground upwards; near the earth the decrease is slower in winter than in summer. (*Annuaire de la Société Météor. de France*, xxxix. 317.)

R. C. Mossman contributes a paper to the Scottish Meteorological Society on "Silver-Thaw at the Ben Nevis Observatory." The phenomenon of silver-thaw, or rain falling when the air is below freezing point and congealing when it falls, is of somewhat common occurrence at Ben Nevis Observatory. The phenomenon points to an inversion of temperature at the time, so that the temperature on the hill-top is considerably lower than at higher altitudes. In the six years, 1885–1890, 198 cases of silver-thaw were observed, lasting in the aggregate 873 hours, or a mean duration of 4½ hours for each case. In December, January, and February the average duration of each case was six hours, whereas during the other months of the year it did not continue more than three hours. Silver-thaw was almost wholly confined to the winter months; nearly all the cases occurred from November

to March. An examination of the daily weather-charts shows that of the 198 days with silver-thaw, the distribution of pressure was cyclonic on 137 days, and anti-cyclonic on 61 days. An examination of records prepared from observations made at the lighthouses around our coasts shows that 73 per cent. of the cyclonic and 63 per cent. of the anti-cyclonic cases of silver-thaw on Ben Nevis were followed or preceded by gales at some of the 27 selected stations on our northern and north-western coasts. The lowest temperature at which this phenomenon took place was 18°. It was of rare occurrence below 27°; fully 90 per cent. of the cases occurred between 28° and 31·9°, hence the greater number of cases occurred just before thaw. (*Jour. Scot. Met. Soc.*, No. viii. 115.)

A. B. M. discusses the relation existing between the solar sun-spot cycle and the air-temperature of the earth. For the enquiry the Greenwich temperatures are used from 1812. It is found that prior to 1870 the maxima of temperature lag a little, as a rule, behind minima of sun-spots, and minima of temperature behind maxima of sun-spots. Since about 1870 the correspondence appears to fail. We look for a temperature maximum about 1879 and we do not find it. With respect to rain-fall it is said to be difficult to trace a very definite relation between it and the sun-spot curve. (*Nature*, xlv. 271.)

Climatological.

C. Theodore Williams, as President of the Royal Meteorological Society, delivered an address on the value of meteorological instruments in the selection of health resorts. He drew attention to thermometers, maximum and minimum, as the foundation stone on which medical climatology rests, and instanced effects of extreme cold or heat on the human organism. The direct rays of the sun are of the greatest importance, and in health resorts should be utilised to the full; in fact, only climates where during the winter months even a delicate person can lie or sit for several hours a day, basking in the sunshine, are to be recommended for most complaints, and the various forms of sunshine-recorders are used to aid the medical adviser in the choice of such health stations. (*Quart. Jour. Roy. Met. Soc.*, xviii. 154.)

F. C. Bayard has investigated English Climatology 1881–1890. This is a discussion of the results of the climatological observations made at the stations of the Royal Meteorological Society, and printed in the Meteorological Record for the ten years 1881–1890. The stations now number about 80, but there are only 52 which have complete results for the ten years. The author gives the monthly and yearly means of temperature, humidity, cloud,

and rainfall. With respect to mean temperature, the sea-coast stations are warm in winter and cool in summer, whilst the inland stations are cold in winter and hot in summer. At all stations the maximum temperature occurs in July or August, and the minimum in December or January. Relative humidity is lowest at the sea-coast stations, and highest inland. The south-western district seems the more cloudy in winter, spring, and autumn, and the southern district the least cloudy in the summer months; and the sea-coast stations are, as a rule, less cloudy than the inland ones. Rainfall is smallest in April, and, as a rule, greatest in November, and it increases from east to west. (*Quart. Jour. Roy. Met. Soc.*, xviii. 213.)

The Weather Bureau of the United States has discussed the climate and meteorology of Death Valley, California. The valley is situated between latitude 35° 40′ and 36° 35′ N., and longitude 116° 15′ and 117° 5′ W., and is said to lie 100 feet, or more, below the level of the sea. It is characterised by excessive heat and dryness. The thermometer rises occasionally to 122° in the shade, and rarely falls below 70° during the hot season. Observations made during the five months from May to September, 1891, give a total rainfall of only 1·4 inches.

The Chief Signal Officer of the United States has published a series of 37 charts, showing the absolute maximum and minimum temperatures in the United States for decades, and for all years combined, compiled from observations taken from 1872 to 1891. Also diurnal fluctuations of atmospheric pressure at 29 stations in the United States. The tables give the corrections necessary to reduce the mean pressure at any hour of the day to the true daily mean. It is found that the daily variation in pressure decreases with increasing latitude, especially in the winter months. Some peculiarities are also noticed in the fluctuations of the principal and secondary maxima and minima.

Rainfall.

A. R. Binnie read a paper at the Institution of Civil Engineers which has been printed in the Minutes of Proceedings, vol. cix. part 3, on the Mean or Average Annual Rainfall, and the fluctuations to which it is subject. The author says, as to the mean or average depth of rain which falls at any station, it may be confidently asserted that the amount in no way depends on mere geographical position as defined by a statement of the latitude and longitude of the station, for great variations exist within very narrow limits. For instance, in England the mean fall varies from about 20 inches in the eastern counties up to more than 160 inches in the Lake district; in France from about 19 inches at Marseilles to

43 inches at Lampy-Neuf; in Italy from 23 inches at Palermo to 62 inches at Udine; in India, at Bombay, at the sea-level, it is about 73 inches, at Mahableshwar in the Western Ghâts, at an elevation of 4,300 feet, it is 254 inches, and at Poonah, less than 70 miles distant, at an altitude of 1,800 feet, it is 19 inches.

G. J. Symons, in British Rainfall for 1891, gives a statement showing the number of records to be as follows:—

	England	Wales	Scotland	Ireland	Gross Total
	2091	168	359	181	2799
Stations per 100 square miles.	4.2	2.0	1.2	0.6	2.3

This shows that Scotland and Ireland are still far behind England, so far as available rainfall records are concerned, for while England has about one observer for each 25 square miles, Scotland has only about 1 to 80 miles, and Ireland 1 to 180 square miles. Mr. Symons is still anxious to add to his army of observers, since gaps are constantly occurring through removals and deaths.

Weather and disease.

A. Buchan investigates influenza and the weather of London in 1891. The author remarks that the diseases which had an increased fatality during the winter influenza epidemic of 1890 were precisely the same diseases which showed an increased fatality during the influenza of the spring and summer of 1891. It does not appear, therefore, that during the spring and summer influenza of 1891 there was an increased death-rate from those diseases whose normal mortality at that time of the year is either large or rapidly increasing; and it seems to follow that the diseases complicating or induced by influenza are independent of season or weather. In other words, the prevalence and fatalness of pneumonia, and the other diseases referred to, during influenza epidemics, are due to something quite apart from weather influences, and that something belongs to the influenza. (*Jour. Scot. Met. Soc.*, viii. 141.)

Hon. F. A. Rollo Russell has discussed the untenability of an atmospheric hypothesis of epidemics. He is of opinion that no kind of epidemic or plague is conveyed by the general atmosphere, but that all epidemics are caused by human conditions and communications capable of control. The author admits that at first sight there is something in the manner of invasion of influenza which seems to suggest a general cause, such as might be found in a contamination of the atmosphere, or large portions of it, with living organic dust. But examination of the

geographical distribution of the disease, of its course through a country, a town, or a village, is sufficient to dispel this illusion, and to lead to the conviction that in influenza we have simply an example of a highly infectious malady of short incubation period and long striking distance through confined air.

The dates of the outbreaks in 1890 are given for a large number of islands and other places in various parts of the world. Like other maladies of high infective capacity, influenza has spread most easily, other things being equal, in cold calm weather, when ventilation in houses and railway-cars is at a minimum, and when perhaps the breathing organs are most open to attack. But large and rapid communications seem to be of much more importance than mere climatic conditions. (*Quart. Jour. Roy. Met. Soc.*, xviii. 124.)

General and miscellaneous.

The Meteorological Council have issued a work, "Ten Years' Sunshine in the British Isles, 1881—1890." The monthly results of the working of the Campbell-Stokes Sunshine Recorder are given for each month at 46 stations. The tables give the total sunshine recorded, and also the percentage of the possible amount for each month. The results show:—That the sea-coast receives more sunshine than the inland parts of the country. Large manufacturing cities like London and Glasgow cannot fairly be compared even with stations in their immediate neighbourhood, particularly in winter; possibly all town records are affected to a certain extent by smoke. The south and west coast stations, and especially the Channel Islands, are particularly favoured in almost all months of the year. The east coast of Great Britain is comparatively sunny. In the summer and early autumn the north-west of Ireland and of Scotland, with the Orkneys, receive very little sunshine. In the late autumn Ireland generally receives more sunshine than most of England.

Edward Mawley discusses in considerable detail the valuable Phenological observations collected by the Royal Meteorological Society. The observers are required to note each year the flowering of the same individual trees and shrubs, and in the case of herbaceous plants, those situated in the same spots. Returns are at present received from 92 observers in England, from 7 in Scotland, and from 6 in Ireland. Mr. Mawley remarks that additional observers are much wanted in the north of England, as well as in all the Scotch and Irish districts. (*Quart. Jour. Roy. Met. Soc.*, xviii. 99.)

W. H. Dines read a paper at the April meeting of the Royal Meteorological Society on Anemometer comparisons. This was a

report on a valuable series of experiments which have been carried out at the request of the Council of the Society, with the view of obtaining a direct comparison of the various anemometers in common use, so that some opinion might be formed as to which type of instrument is the most suitable for general purposes. The anemometers which were compared were:—(1) Kew pattern Robinson, (2) self-adjusting helicoid, (3) air meter, (4) circular pressure plate (one foot in diameter), and (5) a special modification of tube anemometer. Most of these instruments are of the author's own invention, as well as the apparatus for obtaining automatic and simultaneous records from all the instruments upon the same sheet of paper. It appears that the factor of the Kew pattern Robinson is practically constant, and is found to lie between 2·0 and 2·2, instead of 3 as used at present for the records of these instruments. The helicoid anemometer is quite independent of friction for all excepting light winds, and different sizes read alike, but it is not so simple in construction as the Robinson or cup form. The air meter consists of a single screw-blade formed of thin aluminium, and made as nearly as possible into the exact shape of a portion of a helicoid. A similar instrument with a larger blade, and with the dial protected from the weather, would probably form a useful and correct anemometer. It would be light, and offer a very trifling resistance to the wind. It seems probable that the remarkably high values sometimes given by the Osler pressure-plate may be due to the inertia of the moving parts. The tube anemometer appears to possess numerous advantages. The head is simple in construction, and so strong that it is practically indestructible by the most violent hurricane. The recording apparatus can be placed at any reasonable distance from the head, and the connecting pipes may go round several sharp corners without harm. The power is conveyed from the head without loss by friction, and hence the instrument may be made sensitive to very low velocities without impairing its ability to resist the most severe gale. (*Quart. Jour. Met. Soc.*, xviii. 165.)

Baldwin Latham, as President of the Royal Meteorological Society, delivered his presidential address on "Evaporation and Condensation," on January 27th. It was pointed out that with sea-water evaporation is about 4½ per cent. less than with rain-water, while with water saturated with common salt the evaporation is 15 per cent. less than with rain water. From observations conducted at Croydon it is shown that the average amount of water evaporated annually during 1879-91 was 19·948 ins. It was found, however, that, as a rule, during the period from

October to March there were certain occasions when condensation was measured. The amount of these condensations in 13 years averaged ·308 inch per annum. (*Quart. Jour. Met. Soc.*, xviii. 53.)

John Aitken read a paper before the Royal Society of Edinburgh, on January 4th, on the number of dust particles in the atmosphere of various places in Great Britain and on the Continent, with remarks on the relation between the amount of dust and meteorological phenomena. The observations here discussed were made in 1890; those for 1889 were given in a previous paper read on February 3rd, 1890. The Rigi Kulm observations show the daily maximum of dust very clearly. On all the days, except one, the number of particles was least in the morning, and increased greatly as the day advanced, owing to the ascent of valley-air on the sun-heated slopes of the mountain. The impure air had generally arrived at the mountain-top before mid-day, and by mid-day the number was generally three times greater than it was in the morning. A comparison is made of the amount of dust at Kingairloch and Ben Nevis—as a rule there was much less dust at the high station than at the low one, and when the dust increased at the low station it also generally increased at the high one, and *vice versa.* Certain relations between isobars and dust are pointed out. With regular isobars for westerly and northerly winds the air is pure, and the closer the isobars the purer is the air; whilst isobars for southerly or easterly winds, even though close, do not indicate pure air. The highest maximum temperatures occur on days of high dust, and the lowest minimum when the dust is at a minimum. (*Nature*, xlv. 299.)

A. von Frank, of Graz, explains the floating of the particles of cloud or fog by the presence of an envelope of aqueous vapour. As an approximate average value for the diameter of droplet with envelope he gives 0·7mm. Supposing one cubic metre of cloud to hold 3 grammes of water, it is assumed there would be an interval of 0·2 mm. between the envelopes. When clouds pass over the sun, the shadows of objects are perceptibly lengthened when the darkening occurs; this is attributed to refraction by the vapour envelopes. The envelopes expand with heat, and under these conditions the cloud rises. The vapour envelopes are said to prevent freezing till the envelope is ruptured. (*Meteor. Zeitsch.*, 396.)

A. L. Rotch communicates an article on "The Mountain Meteorological Stations of the United States." There are at present only two summit meteorological stations in operation throughout the year in the United States: these are the Lick

Observatory on Mount Hamilton, California, and the Blue Hill Observatory in Massachusetts. For many years regular observations were made on Mount Washington, the highest of the White Mountains in New Hampshire, which has an altitude of 6,280 feet above the sea. The weather here is probably more severe than at any other observing station in the world. On December 16th, 1876, the mean temperature for the day was – 22°, and the wind blew at the rate of 180 miles an hour. In February, 1876, the temperature fell to —50°, and a wind velocity of 184 miles an hour was recorded. For 15 years the Signal Service maintained a meteorological station at Pike's Peak, Colorado, at an altitude of 14,134 feet, the highest meteorological station in the world. (*Amer. Met. Jour.*, viii. 396.)

Cleveland Abbe writes a paper on "Atmospheric radiation of heat and its importance in meteorology." According to the author, a comprehensive study of fluid motions shows that air and water alike may be forced to ascend without being warmer and lighter, or to descend without being colder and denser, than the surrounding fluid. The currents and whirls behind any obstacle in streams of air or water are almost wholly independent of differences of density, and are caused by differences of pressure as modified by simple kinetic laws. Prof. Abbe brings together practically all the conclusions that have been arrived at on atmospheric movements and their relation to radiation from the air. (*Amer. Jour. of Science*, May, 1892.)

C. Meldrum read a paper at a meeting of the Meteorological Society of Mauritius, on April 7th, relative to the sun-spots, magnetic storm, cyclones, and rainfall of February, 1892. The photographs of the sun taken at the Royal Alfred Observatory from February 5th to 18th showed the very large group of spots. The ranges obtained from the magnetic records were the largest ever recorded there. Two cyclones were experienced, and there was a third about 550 miles south of Mauritius. The rainfall for February, as shown by returns from numerous stations, was from 4·30 to 16·96 inches above the average.

CHEMISTRY.

PHYSICAL CHEMISTRY.

By Prof. W. RAMSAY, Ph.D., F.R.S.

Atomic weights.

The important ratio of the relative weights of hydrogen and oxygen has been redetermined by **Lord Rayleigh** and by **Leduc.** Lord Rayleigh weighed the two gases in a large balloon, and found the density of oxygen relative to that of hydrogen to be 15·882. Combining this ratio with Morley's volume-ratio, 2·0002, $O = 15{\cdot}880$, or if $O = 16$, $H = 1{\cdot}0075$. (*Proc. Roy. Soc.*, l. 449.) A. Leduc's numbers are $O = 15{\cdot}905$ ($H = 1$). He also finds the density of nitrogen $= 0{\cdot}9720$. (*Comptes Rendus*, cxiii. 198.) It now appears certain that the atomic weight of oxygen must lie between 15·87 and 15·90.

The atomic weight of boron has been determined by **J. L. H. Abrahall,** and also by **Miss Aston** and **W. Ramsay.** In both cases the water in borax was determined, although no great stress is laid on the results. Abrahall found $B = 10{\cdot}554$ to 10·843; while Aston and Ramsay obtained the number 10·95 to 11·04. By estimating bromine in bromide of boron, Abrahall made $B = 10{\cdot}792$ to 10·838; Aston and Ramsay converted borax into sodium chloride by distilling it with methyl alcohol and hydrochloric acid, and found $B = 10{\cdot}936$ to 10·992, or, applying a correction which appears necessary, 10·997. Abrahall gives no proof that his bromide did not contain HBr.

Richards (*Proc. Amer. Acad.*, xxvi. 240) has confirmed his previous determinations of the atomic weight of copper—viz., 63·60, and he has also determined the specific heat of aluminium; it is expressed by the formula, $Q = 0{\cdot}220 + 0{\cdot}0001t$. The atomic heat found varied between 6·0 and 7·7.

The atomic weight of palladium has been determined by **G. H. Bailey** and **Thornton Lamb** (*Trans. Chem. Soc.*, lxi. 745), by estimating the metal in chloride of palladammonium. The mean of three series is 105·459.

Moissan (*Annales* [6], xxv. 125) has determined the density of fluorine—viz., 18·394, instead of 19.

The molecular weight of albumen has been determined by **Sabanejev** and **Alexandrov** (*Jour. Russ. Soc.*, ii. 7), the depression of the freezing point having been found. It appears to be not less than 14000. Similar experiments with colloids gave molecular weights of about 30000.

Gases.

Diffusion.—**Biltz** (*Zeitsch. Phys. Chem.*, ix. 152) has described some pretty experiments illustrative of diffusion. One consists in breaking bulbs of bromine in jars filled with air and hydrogen, when the vapour will be seen to rise much more rapidly through the hydrogen than through the air. Another deals with the diffusion of gas through a porous cell; while a third is so arranged that gases, chiefly hydrogen and carbon monoxide, pass through the walls of an iron tube and raise pressure in its interior, shown by the rise of mercury in a gauge attached to the tube. The analogy with the osmotic pressure of liquids is thus illustrated.

Change of Physical State.—Not long ago Thorpe determined the density of hydrogen fluoride, and found that the gas, at low temperatures, probably contains molecules of H_4F_4. An interesting set of experiments has been made by **H. Biltz** (*Zeitsch. Phys. Chem.*, x. 354), to see if hydrogen chloride, bromide, and iodide exhibit any signs of increase of density at low temperatures. Experiments made as near the points of liquefaction of these gases as possible gave very little indication of increased molecular complexity; the behaviour of hydrogen fluoride appears to be unique in this group of elements.

E. H. Amagat (*Comptes Rendus*, cxiii. 446) has reinvestigated the thermal behaviour of carbon dioxide, giving long tables of the constants. The work is evidently very accurate, and will serve to test the numerous hypotheses relating to the interdependence of p, v, and T. (*See* also p. 27.)

Liquids.

Vapour-pressure and Boiling-point.—**S. Young** has continued his investigations of the validity of Van der Waals' formula applied to various substances for which the necessary data are known. (*Proc. Phys. Soc.*, 1892, 233.) He finds that the statement, "If the absolute temperatures of various substances are proportional to their absolute critical temperatures, their vapour-pressures will be proportional to their critical pressures," holds only in a very limited number of cases. But somewhat nearer results are obtained in comparing their molecular volumes, although the deviations from constancy are not within the limits of experimental error. The molecular volumes of saturated

vapour are also not in accord, though the discrepancy is relatively small. Better results are obtained if a comparison is made at corresponding pressures than at corresponding temperatures.

The thermal behaviour of water and steam has been investigated by **Ramsay** and **Young** (*Phil. Trans.*, 1892). Measurements are given of the expansion of water with rise of temperature; of the vapour-pressure of water up to 270° C., and of the densities of the unsaturated and saturated vapour up to the same limit of temperature. The most striking feature of the research is that the lines of equal volume are not straight—*i.e.*, the relation between temperature and pressure is not a linear one.

The critical temperature of mixtures has been investigated by **G. C. Schmidt** (*Annalen*, cclxvi. 266). He has tested the rule laid down by Pawlewski, that the critical temperature of a mixture may be calculated by the usual law of mixtures. He has failed to substantiate this statement after experiments with mixtures of ether, benzene, and diethylamine with a number of other substances.

Volume-relations of Liquids.—Last year ("Year-Book" for 1891, p. 135) **G. Hinrichs** gave formulæ by help of which the boiling-points and melting-points of carbon compounds can be calculated. This year (*Zeitsch. Phys. Chem.*, ix. 81) he developes a theory of volumes. A paraffin consists of a prism, containing n identical terms CH_2, terminated at each end by a hydrogen atom. If k is the volume of the group CH_2, and h that of the end atom, then the molecular volume of a normal paraffin is given approximately by the equation, $v_n = k.n + 2h$. But as each prism attracts its neighbours, its volume is further diminished by a small amount; so that the final equation is $v_n = k.n + 2\,(h' + e)$, where $e = k'\,(v - n)^2$. The actual volumes of the paraffins are reproduced thus with great accuracy. Similar results are obtained by the dynamical consideration, "The molecules of liquids rotate round their natural axis, the moment of whose inertia is a minimum."

Surface-relations of Liquids.—A careful investigation of the change in surface-tension of water with temperature has been made by **B. Weinberg** (*Zeitsch. Phys. Chem.*, x. 34), which, however, adds nothing of theoretical interest to our knowledge.

H. Landolt and **H. Jahn** have published a long paper in the *Zeitschr. Phys. Chem.*, x. 289, on the relationship between the dielectric constant of a number of organic liquids and the constant A of Cauchy's dispersion formula; they find that for hydrocarbons the cube-root of the dielectric constant is equal to the constant A, but with unsaturated compounds this relation no

longer holds good, the former being always greater than the latter. They are not prepared yet to enter into the reasons of this difference.

Solutions.

Solubility of gases.—**L. W. Winkler** has continued his experiments on the solubility of gases, and finds (*Zeitsch. Phys. Chem.*, ix. 171) that the percentage decrease in the coefficient of solubility between 0° and 20° is approximately proportional to the cube root of the molecular weight of the gas. The agreement is good in the case of aqueous solutions of hydrogen, nitrogen, carbon monoxide, nitric oxide, and oxygen. The authors believe that the real cause of the decrease of absorption with rise of temperature is change in internal friction. If m and m' represent the internal friction of water, and b and b' the absorption coefficients of a gas at two temperatures, then if M is the molecular weight of the gas, $(b-b')\,b=(m-m')\,m\sqrt[3]{M}/k$, or $k=(m-m')/m.b\div(b\text{-}b')/M$. The values of k for these gases between 0° and 20° are nearly the same; and the coefficient of solubility calculated by means of this constant from the internal friction of water up to 60° agrees very well with the experimental numbers.

C. Bohr and **I. Bock** (*Wied. Ann.*, xliv. 318) have found that the coefficient of absorption of hydrogen, unlike that of other gases, decreases from 0° to 60° and rises between 60° and 100°. The decrease is from 0·0203 at 0° to 0·0144 at 60°; and the increase from 0·0144 at 60° to 0·0166 at 100°.

Solutions of solids.—Up to the present date no attempt to connect the solubility of solids in liquids with the temperature has been successful. **C. M. van Deventer** and **H. J. van de Stadt** have examined the possibility of expressing the relations between the solubility and the temperature by a curve corresponding with some general formula. Their conclusion is that inasmuch as proportionality between heat absorbed during solution and solubility does not exist, it is hopeless to attempt to discover a general curve, although certain formulæ of limited application exist which are available in special cases.

Several researches have been made on the solubility of double salts, or of salts simultaneously present in solution. One of these by **F. A. H. Schreinemakers** (*Zeitsch. Phys. Chem.*, ix. 57) treats of the equilibrium of the double salt of lead and potassium iodide in aqueous solution. Here there are two systems, in each of which equilibrium must occur:—first with three components, H_2O, PbI_2, and KI, (1) water-vapour, (2) the solution, (3) the double salt, and (4) PbI_2. Second, the constituents (1) (2) and (3) again, but for the fourth, KI. This double salt PbI_2, 2KI,

$2\frac{1}{2}$ H_2O, from the author's experiments, appears to be capable of existing in solution over a considerable range of temperature without decomposition, and it is the first instance in which this has been observed.

W. Nernst (*Zeitsch. Phys. Chem.*, ix. 137) has an interesting article on the solubility of mixed crystals. In order to give an idea of the progress of theory in this direction it is necessary to sketch Van't Hoff's application of the osmotic theory to solids. Many mixtures, such as alloys and "isomorphous mixtures," may be regarded as resulting from molecular interpenetration. But how can such solid substances be supposed to exert partial pressure? This is inferred from the fact that they flow, although exceedingly slowly; for example, hydrogen, dissolved in palladium, diffuses from one part of the metal to another; carbon at a high temperature penetrates porcelain, and so with other instances. It is therefore probable that the partial pressure which causes such diffusion is analogous to gaseous pressure, as is osmotic pressure. It follows that the vapour-pressure and the solution-pressure of solids, if foreign bodies be present in intimate molecular mixture, must be lowered according to the same laws as those of liquids. The law of partition will therefore be valid if a dissolved substance is present, in not too great concentration; it will maintain equilibrium with its gaseous or liquid surroundings. If two salts, A and B, are present at once in aqueous solution, all proportions capable of crystallising together in four states of saturation are conceivable, viz. :—

(1) The two pure salts A and B.
(2) An isomorphous mixture of A and B.
(3) An isomorphous mixture and the pure salt A.
(4) An isomorphous mixture and the pure salt B.

Sometimes all these conditions are realisable, but in a given case only the salt 2, into which all the other systems will pass, if sufficient time be given. In the paper alluded to Nernst developes equations for the case of isomorphous salts with water as solvent, in which, of course, electrolytic dissociation has to be allowed for. He applies these considerations to Roozeboom's observations on the solubility of thallium chlorate containing potassium chlorate, and shows that the maximum work obtainable from the expansion by a definite fraction of its volume of a gram-molecule of potassium chlorate in dilute solid solution in thallium chlorate is approximately the same as that obtainable from the expansion of a perfect gas at the same temperature by the same fraction.

Experiments of a similar kind are described by **R. Behrend**

(*Ibid.*, 405, and x. 265), and also by **Roozeboom** (*Ibid.*, x. 145), and on partially miscible solutions, by **H. Pfeiffer** (*Ibid.*, 444).

Osmosis.—An interesting paper has been published in the *Zeitsch. Phys. Chem.*, ix. 97, by **G. Tammann**, on the measurement of osmotic pressure. The osmotic pressure of solutions of potassium nitrate and similar salts has been observed by Pfeiffer, Adie, and others to be less than that required by Arrhenius' theory of ionisation. Tammann shows this to be due to the fact that copper ferrocyanide, the substance of which the membrane is composed, is not perfectly impermeable to the salt (or its ions), and thus the observed pressure is less than the osmotic pressure. By determining the rate of diffusion of the salt through the membrane, a correction may be applied, which reconciles experiment with theory. A new method of measuring osmotic pressure is also proposed, viz., to place on each side of a membrane solutions of different osmotic pressure, and to counterbalance the higher by external pressure. The process seems to work well.

Van't Hoff has applied such corrections to Adie's results, of which a description was given in the "Year-Book for 1891, p. 139, and has found that they all corroborate his theory. (*Ibid.*, ix. 477.)

Tammann has also an interesting paper (*Ibid.*, x. 255) on the question as to whether, as asserted by Traube, the permeability of membranes to some substances and not to others is caused by a kind of filtration, those bodies with small molecules passing, while bodies with large molecules are stopped. His experiments render such a hypothesis improbable; and he refers the different behaviour to the solubility or insolubility of the substance in the material of which the membrane is composed. The amount of water in the membrane is determined by the vapour-pressures of the surrounding solutions. If a solution A has a greater osmotic pressure than a solution B, water will first pass from B to the membrane, and then diffuse from it to the solution A till, if osmotic equilibrium occur, both solutions and the membrane which separate them possess the same vapour-pressures. But this can only occur if the membrane is permeable, and we are ignorant of the cause why one substance is able to dissolve another.

S. Arrhenius has published in the same journal (x. 51) the results of an investigation of diffusion in aqueous solution. When an electrolyte (*e.g.*, alcohol) replaces the water of a salt solution, the rate of diffusion into the mixed solvent is less than when water alone is used. The formula expressing the influence of the non-electrolyte is similar to that which represents the effect of the addition of a non-electrolyte on the electrical conductivity of an aqueous solution. The addition of an electrolyte is usually

to diminish the rate of diffusion, but if hydrochloric acid diffuses, not into water, but into a solution of salt, the rate increases. This apparent anomaly is explained on the assumption of electrolytic dissociation, and the constants for a number of similar cases are calculated.

Vapour-pressures.—According to the well-known equation of Van der Waals, $p = RT/(v-b) - a/v^2$, if pressure, volume, and temperature are expressed in terms of their critical values, the values of a, b, and R may be given as $a = 3p_c v_c^2$; $b = \frac{1}{3}v_c$; $R = p_c v_c / t_c$. Introducing these terms into the original equation it becomes, $\pi = 8\tau/(3w-1) - \frac{3}{w^2}$, if $\pi = p/p_c$; $w = v/v_c$; and $\tau = t/t_c$, the suffix c referring to the critical constants. Here all reference to any specific substance is eliminated, but it is now clear that Van der Waals' equation is not true to fact, nor can it be deduced from thermodynamical principles. But **L. Natanson** assumes it to hold where p is vapour-pressure, and w and W the volumes of the saturated liquid and saturated vapour, respectively. By means of equations involving these terms he calculates orthobaric curves for various substances for which data exist, expressing temperature and volume in terms of their critical values, and finds that under these circumstances the curves do nearly coincide. The extension of Van der Waals' theory to solutions by Masson renders it probable that this process is also applicable to solutions. Natanson has constructed orthobaric lines for all pairs of liquids for which data are procurable, and has found that when the temperatures and volumes are given in terms of their critical solution values, the orthobars are coincident. This appears to be a new support to Van't Hoff's theory of the analogy between gases and solutions. (*Zeitsch. Phys. Chem.*, ix. 26.)

Further proofs of this analogy are given by **P. de Heen** (*Bull. Ac. Belg.* [3], xxiii. 136). In studying evaporation he found that the amount of liquid evaporated is proportional to the product of the maximum solubility and the molecular weight. To test this for solutions, cylinders of given weight of $LiCl$, $NaCl$, KCl, KBr, KI, and other salts were suspended in the solvent, and were found to obey the law.

Ewan and **Ormondy** (*Chem. Soc.*, lxi. 769) have devised a new method of determining the vapour-pressure of solutions. They determine the dew-point of the vapour evolved, by cooling a silver vessel in the space above the solution. Their results agree remarkably well with those of other observers obtained by a different method.

Freezing-point of solutions.—**F. M. Raoult** (*Zeitsch. Phys.*

Chem., ix. 343) has described carefully the means of obtaining correct results in determining the freezing-point of solution. The temperature at which freezing is induced should not exceed 0·5° below that to which the thermometer will ultimately rise. Very concordant results are given for sugar up to a concentration of 39 grams in 100 of water.

L. E. O. de Visser has verified the thermodynamic equation $L/(S-s)=dp/dT.T/J$ by determining the rise of temperature corresponding to unit rise of pressure of liquid acetic acid, and the volumes of one gram of the liquid and the solid; and lastly, the heat of fusion. The value of dp/dT directly found was 0·02435; and calculated from the volumes and the heat of fusion, 0·0242. The value of J was taken as 425·5. Perfectly pure acetic acid melts at 16·5965; the expansion per calory was directly determined as 0·003442c.cm.; and the heat of fusion was found to be 46·42 calories per gram. This very careful piece of work adds another to the now fairly numerous proofs of the validity of the well-known equation. (*Inaugural dissertation, Utrecht.*)

Two admirable papers have been contributed to the Chemical Society by **Messrs. Heycock** and **Neville** (*Trans. Chem. Soc.*, lix. 936, and lxi. 888). An immense number of experiments on the lowering of the freezing-points of cadmium, bismuth, and lead by other metals have led the authors to the following conclusions :—Three different effects may follow from alloying metals with one another: (1) the freezing-point is lowered, as is usually the case ; (2) the freezing-point is raised, *e.g.*, by silver in cadmium, antimony in tin, antimony in bismuth ; (3) the freezing-point is unaltered, *e.g.*, by thallium in lead. In the first of these cases the first portions of the alloy which solidify are poorer in the dissolved metal than the fluid part. In the second case the portions solidifying contain more of the dissolved substance than the liquid portion; and in the third case the liquid and the solid portions have the same composition. These facts lend entire support to Van't Hoff's theory of solution. The results of **Von Bijlert**, described in the "Year-Book" for 1891, p. 145, are thus confirmed and amplified.

The nature of colloidal solutions.—This subject has been carefully examined by **H. Picton** and **E. Linder** (*Chem. Soc.*, lx. 114), and some interesting experiments have been made by **C. E. Linebarger** (*Sill. Jour.*, xliii. 218). Starting with an attempt to prepare hydrosulphides, analogous to hydroxides, Picton and Linder found that sulphides, prepared by passing a stream of hydrogen sulphide through a hydroxide suspended in water, or in some cases by adding the solution of a metallic salt to a solution of hydrogen sulphide, formed *quasi* solutions. In other cases hydrogen

sulphide was passed through water in which the sulphide was suspended. Such *quasi* solutions contain hydrosulphides, which, however, are decomposed by a current of hydrogen, leaving a clear liquid transparent in thin layers, and depositing no precipitate on standing. The sulphides of mercury, arsenic, and antimony were found to give no depression of freezing-point, thus implying a very high molecular weight. Seen under a very powerful microscope, the sulphides of mercury and arsenic (one variety) contained particles of apparently the same uniform size, all in rapid motion. With antimony sulphide the particles were invisible, but it was possible to detect a moving granulation, and on standing, slow coalescence took place, the aggregations gradually becoming visible. One form of arsenic sulphide had the property of diffusion, not possessed by others. All these *quasi* solutions, if examined by a polariscope when illuminated at right angles to the direction of the ray, are found to polarise light, implying the existence of solid particles. Colloidal ferric hydrate gave a fluorescent solution, perfectly transparent by transmitted light, but polarising light completely. But on filtration through a porous cell, the filtrate contained no iron. On coagulation with a solution of calcium chloride, no heat change took place, and the solution was incapable of diffusion. The hydroxides of chromium and aluminium showed similar behaviour. On the other hand, colloidal silicic acid showed no beam; and it could be filtered through a porous cell. Colloidal molybdic acid, too, showed no beam, and passed through a porous cell.

Cellulose dissolved in Schweitzer's solution, and soluble starch, both gave a beam. A neutral solution of Congo-red with a molecular weight of 766 gave a well-marked beam, and refused to pass through a porous cell; an acid solution also polarised light; but an alkaline solution showed no luminous beam, nor did it refuse to pass through a porous pot. With hæmoglobin, which is a crystalline substance, the aggregates are large enough to polarise light, yet are too large to pass through a porous pot; and Magdala-red, a much less complex body, showed neither phenomenon. Another very curious property of such solutions is that they are repelled from one of the poles of a battery as a whole, when "dissolved" in some non-conducting solvent, such as pure water or absolute alcohol. Arsenious sulphide, for example, is repelled strongly from the negative and slightly from the positive pole, while Magdala-red is repelled from the positive electrode, but not from the negative. The authors are continuing these interesting and most suggestive researches.

Linebarger has measured the osmotic pressure of a solution of

colloidal tungstic acid, and finds it to correspond with a molecular weight of about 1,700 implying the formula $(H_2WO_4)_7$. (*Zeitschr. Phys. Chem.*, ix. 751.)

The dissolution of a salt in water is now commonly held to be accompanied by more or less complete ionisation, that is, the metal of the salt separates from the radical; the metal and the radical are named ions, and possess the property of carrying an electric current. The rate at which the current passes depends on the number of ions per unit volume of the liquid, and also on the ease with which they can pass through the liquid. The opposition to their passage is caused by the internal friction of the liquid. Hence it is obviously a matter of importance to determine this coefficient of friction. **Carl Lauenstein**, in Prof. Ostwald's laboratory, has made numerous experiments on the friction of the sodium salts of many organic acids, by determining their rate of flow through a capillary tube. The influence of the substitution of various groups for hydrogen on the internal friction is discussed, and compared with the conductivity of the solutions. (*Ibid.*, ix. 417.)

Solids.

Crystals.—**J. W. Retgers** has continued his researches on the isomerism of crystals (*Zeitschr. Phys. Chem.*, ix. 267 and 385). In his first paper he describes attempts to influence the form of crystals by the presence of foreign bodies, and gives tables showing the change of form of halides of the alkaline metals, produced by causing them to crystallise in presence of urea, ferric chloride, chromic chloride, etc. For example, while the presence of urea changes the form of NaCl to octahedra, and of KCl to cubo-octahedra, the forms of KBr, KI, NH_4Cl, NH_4Br, and NH_4I remain, as usual, cubes. With ferric chloride, NH_4Br, and NH_4I change to trapezohedra and octahedra, while all the other halides remain unchanged. In his second paper he has tested the law which states that chemical analogy is necessary in order that isomorphous crystallisation may occur, and also its complement, that when complete mixture is observed it may be concluded that the mixed substances are chemically analogous, and he finds that the law is practically without exception.

That solids may sometimes dissolve solids is an opinion expressed lately by Van't Hoff. **E. A. Schneider** has made some interesting experiments on the precipitation of barium sulphate in presence of ferric sulphate (*Zeitschr. Phys. Chem.*, x. 425). The precipitate always contained a constant percentage of iron, however much ferric sulphate was present during precipitation; so long, of course, as the maximum amount of iron which the

precipitated barium sulphate was capable of taking up had been reached. It was shown that no basic ferric sulphate was thrown down, and also that no double salt of barium and iron is capable of existence. The details of the proof of this last assertion are, however, not given, and it appears to the writer that this explanation, though unlikely, is nevertheless not excluded. It would be well to strengthen the evidence in favour of the possibility of solution of a solid by a solid with other examples.

Expansion.—The expansion of platinum by rise of temperature has been carefully determined by **Th. Selivanov** (*J. Russ. Soc.*, ii. 152), and the observations are of importance in view of the experiments of J. Joly. The mean linear expansion of platinum between the ordinary temperature and 1,700° lies between 0·00001011 and 0·00000967. The coefficient of expansion increases rapidly up to 150°, and above that temperature more slowly.

Melting points (*Chem. News*, lxv. 1, 16, 30, and 31).—**J. Joly** has devised a most ingenious form of apparatus for determining the melting-points of minerals which fuse at a high temperature, which he has named a "meldometer." A ribbon of pure platinum, 1·2 mms. in width, is stretched between forceps, each furnished with a binding-screw, and insulated from each other, so that on connecting the binding-screws with a battery a current can be passed through the ribbon. Upon the surface of the ribbon the substance to be examined is placed. The ribbon is stretched in the field of a microscope, and a gradually increasing current is passed through the ribbon until the mineral or other substance melts. The method of estimating the temperature depends on the thermal expansion of the ribbon. The increase in length of the ribbon is determined by means of a micrometer-screw, when a salt of known melting-point is seen to melt on its surface, and by means of several experiments of this kind a scale is constructed. The instrument gives very accurate results, and we may hope by its means to gain much knowledge of the melting-points of substances which fuse at a high temperature.

Change of condition.—**Carl Barus** (*Amer. J. of Science*, xlii. 125) has made experiments on the continuity of the liquid and solid states, similar to those of Andrews on the liquid and gaseous states of matter. The substance investigated was naphthalene. There exists a critical temperature for solid-liquid where the two states merge into each other. The isothermals have the same general form as the curves of double flexure suggested for liquid-gas by James Thomson, and the unstable portions of these curves may be investigated much more easily than the corresponding

unstable portions of the liquid-gas curve. Barus has also incidentally found that similar phenomena are observable in the case of glass and water to those described by Alexéeff, and examined by Masson, of which a full account was given last year ("Year-Book," 143). It appears that there exists a critical point for solid-liquid and liquid-solid solutions like those for liquid-liquid solutions.

Allotropy, isomerism, and structure.

About three years ago **Ira Remsen** attempted to account for the existence of double halides by the assumption that the halogens are trivalent, and he predicted that the number of atoms of halogen in the halide of an alkali-metal as constituent of a double halide would always be equal to, or smaller than, the number of halogen atoms in the other constituent. His view was that the constitution of such a salt as KF.HF was $K-F=F-H$; of $CuCl_2.2KCl$, $Cu\,(Cl=Cl-K)_2$, etc. It is evident that, on this supposition, halides such as KF.2HF cannot be represented, except with the improbable formulæ $KF\left\langle\begin{matrix}FH\\FH\end{matrix}\right\rangle$, a view which Remsen himself doubted. His suggestion has proved, on examination, not to hold. There are numerous exceptions like CuCl.2KCl and $CdCl_2.4KCl$, which prove that the supposed law cannot hold good, and with it falls the view regarding the constitution of the double halides. (*Amer. Chem. J.*, xiv. 81.)

An ingenious theory has been published by **P. A. Guye** (*Dissertation*, Paris, 1891, also *Chem. Centr.*, ii. 909). Le Bel and Van't Hoff have shown that compounds which rotate the plane of polarised light possess what is termed an assymmetrical structure, *i.e.*, they contain a carbon-atom in combination with four different atoms or groups of atoms. Such compounds sometimes are able to rotate the plane of polarised light to the left, sometimes to the right. There must therefore exist some sort of strain within the compound, to account for this behaviour. It is possible to represent such a strain by a line, the length of which is proportional to the magnitude of the strain, and the direction of which is that in which the strain is applied. The assymmetric carbon-atom is conceived as existing at the centre of a tetrahedron, and the atoms or groups with which it is combined are imagined at the solid angles of the tetrahedron, their distance from the centre, *i.e.*, from the carbon-atom, representing their magnitude and the strain which they exercise on the carbon-atom and on each other. Now it is possible to replace a group or atom of low molecular weight in such a compound, by one of higher weight or greater complexity. And this can be done so as to displace the apparent centre of gravity, in such a manner that a

body displaying left-handed rotation shall, after the substitution has been made, display right-handed rotation. Guye has been successful in all cases which he has investigated in accomplishing this transformation; and the fulfilment of the predictions, which his theory allows him to make, affords a strong presumption that the theory is a just one.

Heats of combination.

Accounts of experiments in this branch of physical chemistry usually consist of series of numbers. This year there is nothing of general interest; yet it may be mentioned that the heats of formation of hydrazoic acid, of hydrazine, and of hydroxylamine have been determined. **Berthelot** has been first in determining the heat of formation of hydrazine (−589K in aqueous solution) and of hydrazoic acid (−616K in solution). The explosive properties of these bodies are thus explained. (*Comptes Rendus*, cxiii. 672.)

F. Stohmann has made a long series of determinations of the heats of formation of the carbohydrates, a class of bodies with which his name has long been associated. Among others he has worked with arabinose, xylose, d-glucose, d-fructose, etc. The list is a long one; and a still longer is given in the *Zeitschr. Phys. Chem.*, x. 410. The experiments were carried out in a calorimetric bomb. (*J. Prakt. Chem.*, xlv. 305.)

The hepto-carbohydrates have been similarly investigated by **J. Vogh.** (*Comptes Rendus*, cxiv. 920.)

Spectroscopy and light.

Spectroscopy.—Profs. **Dewar** and **Liveing** have examined the spectrum of liquid oxygen, and obtained the usual absorption bands. The blue colour is not due to ozone, because on cooling a solution of ozone in oxygen to 181° the mixture exploded, for at that temperature ozone is unstable, in accordance with its negative heat of formation. This is particularly interesting, because it follows from the fact that if a stable body becomes less stable as the temperature rises, a body formed with absorption of heat must become less stable as the temperature falls. The coefficient of refraction of oxygen for the D-line is 1·2236; the density at 181° is 1·124; and hence the molecular refraction is 3·382 (n-formula). Similar constants are given for nitrous oxide and ethylene. (*Phil. Mag.*, xxxiv. 205.)

T. Ewan has made a series of experiments on the absorption-spectra of copper salts. (*Phil. Mag.*, xxxiii. 317.) His conclusions are that the spectra of these bodies undergo alteration of such a nature that they tend to become identical as dilution increases,

thus confirming the hypothesis of electrolytic dissociation. The results cannot be satisfactorily explained on the theory of a hydrolytic dissociation, nor on that of molecular aggregates. Similar experiments have been made by **O. Knoblauch** (*Wied. Ann.*, xliii. 738), which lead to the same conclusions when rightly interpreted.

M. Schutze (*Zeitschr. Phys. Chem.*, ix. 109) has investigated the connection between colour and constitution of compounds. He recognises a shifting of absorption from violet to red as in general corresponding to the colour-changes, green-yellow, yellow, orange, red, red-violet, violet, blue-violet, blue, blue-green, etc., as a deepening of the colour; and a shifting of colour from red to violet as a lightening of colour. The introduction of hydrocarbon radicals always deepens the colour; and the elements also deepen the colour in the order of their atomic weights. An addition of hydrogen always lightens the colour. The nearer the substituting group to the chromophore, *i.e.*, to that part of the compound which is the cause of the colour, the greater the influence in lightening or deepening the colour; but in some cases the para-position has a greater influence than the ortho-position.

H. B. Baker (*Chem. Soc.*, lxi. 728) has reinvestigated the action of light on silver chloride, and has come to the conclusion that the darkening of the chloride is due to the formation in very minute quantity of an oxychloride of the probable formula, Ag_3ClO. He believes this to be the case because silver chloride is not blackened when exposed to light in a vacuum, nor when in contact only with dry carbon tetrachloride; and no blackening took place in dry oxygen. The black product is bleached when exposed for a long time to light, and this the author believes to be due to the formation of a white oxychloride. (See also p. 192.)

The *structure of flames* has been investigated by **A. Smithells** and **H. Ingle.** (*Chem. Soc.*, lxi. 204.) Much light has been thrown on what may have appeared to many to be a thoroughly understood matter, but the authors have shown that our knowledge is really very slight. They have devised a sort of Bunsen's burner, in which, by means of two concentric tubes, the flame may be divided into two parts, an outer and an inner, by lighting the flame at the top of the narrower inner tube, and then pushing up the outer wider tube till its end is higher than that of the inner one. The flame continues to burn at the top of the inner tube, inside the wider one; and the gases which are produced by the combustion burn on escaping at the top of the outer wider tube. The first combustion in the inner tube

converts coal-gas into carbon monoxide and hydrogen; and these gases burn further to carbon dioxide and water, on escaping into the atmosphere and meeting with excess of oxygen. Experiments were also made with pure hydrocarbons, such as ethylene, methane, pentane, heptane, and benzene. On increasing the supply of air the upper flame gradually disappears, and complete combustion takes place at the orifice of the inner tube. In a further paper (*Ibid.*, 237) Smithells discusses the cause of the luminosity of flames, which he attributes to the decomposition of the hydrocarbons by the heat of the external flame.

At the meeting of the British Association of which a report is given in *Nature*, xlvi. 402, Smithells described further experiments on the same subject. He introduced a spray of cupric chloride solution into the gas, and showed that the inner flame remained unaltered in appearance, but that the outer flame became green. He believes that the spectrum is due, not to incandescent gas, but to molecular disturbance accompanying chemical change. This contention is supported by experiments of **E. Pringsheim** (*Wied. Ann.*, xlv. 428), who attempted to produce a spectrum by means of strongly-ignited sodium. The salts of sodium gave no spectrum, but the metal did. The possibility of oxidation was, however, not excluded. Pringsheim too believes the spectrum to be due to chemical change, and not to incandescent gas. (*See* p. 44.)

The colour of the ions has been investigated by **W. Ostwald** (*Zeitschr. Phys. Chem.*, ix. 579), by comparing the absorption-spectra of solutions of various series of coloured salts, measuring the spectra of the bands, and also photographing the whole spectrum. It appears that the spectra of dilute solutions of salts with the same coloured ion are identical. This was proved for the salts of permanganic acid, fluorescin, eosin, iodeosin, dinitrofluorescin, orcinphthalein, its tetrabromo-derivative, rosolic acid, diazoresorcin, the chromoxalates, the salts of safrosin, pararosaniline, aniline-violet, chrysaniline, and chrysoïdine.

Electro-chemistry.

The conductivity of a solution for electricity depends on two things:—the number of free ions, such as Cl, K, (NO_3), etc., present in the solution, for it is only they, and not molecules, which convey electricity; and on the resistance to their passage offered by the solution, *i.e.*, the coefficient of friction. **Arrhenius** (*Zeitschr. Phys. Chem.*, ix. 487) has investigated the influence on the conductivity of non-electrolytes such as alcohol, acetone, ether, sugar, etc., replacing water in the electrolytic solution. He has found that if the quantity of non-electrolyte added does

not exceed 10%, the conductivity of the solution may be expressed by the formula $e = e\,(1 - ax/2)^2$, where e is the conductivity, and a an empirical coefficient. The diminution of conductivity is due to two causes, viz., the increase of fluid friction in decreasing the speed of the ions; and also the effect of the non-electrolyte in altering the ionisation of the dissolved substance. In the case of substances which are already much ionised the diminution is due almost entirely to the first cause; and the relation between it and the increase of fluid friction may be expressed by the formula $1000a = C + 1000C'(A-1)$, where A is the fluid friction (compared with that of water as unity) of a solution with 1% of the water replaced by the non-electrolyte, and C and C′ are constants, the same for various groups of electrolytes. Here the addition of a non-electrolyte does not appreciably alter the amount of ionisation, but when the dissolved substance is only slightly ionised the addition of a non-electrolyte not only diminishes the speed of the ions, but also their number. Arrhenius shows how to correct the observed conductivity of a solution for fluid friction, so as to reduce the value obtained to that of a liquid whose fluid friction is equal to that of pure water.

The thermodynamics of electrolytic dissociation is the subject of a paper by **J. J. van Laar** (*Zeitschr. Phys. Chem.*, x. 242); although an important subject, it is impossible to give even an idea of it here.

More than a year ago **Ostwald** published in the *Ber. d. Sachs. Ges. d. Wiss.*, a paper on chemical action at a distance, which has been reprinted in the *Zeitschr. Phys. Chem.*, ix. 540. Ostwald's conclusion, shortly stated, is:—If two liquids are able to produce ions, one positive, the other negative, a current will be produced if these liquids are joined by an indifferent conducting liquid, as well as by a metallic conductor. If a solution is able to dissolve a metal, but only in presence of a second metal, it is necessary that the liquid be in contact, not with the first, but with the second metal. For instance, if zinc be placed in a solution of potassium sulphate, in a vessel connected by a wet wick with another vessel containing a slip of platinum also immersed in a solution of the same salt, no action takes place. In order to commence the action it is necessary to add acid, not to the vessel containing the zinc, but to that containing the platinum. Ostwald also showed that if an oxidising and a reducing liquid are placed between unattackable electrodes, an electric current may be produced without any separation of a substance at the electrodes.

W. D. Bancroft has investigated some cases of this kind (*Zeitschr. Phys. Chem.*, x. 387). Two tubes, each furnished with a platinum electrode, and connected by a narrow tube, into which two lateral tubes, one from each of the wide tubes, dipped, were charged, one with an oxidising solution, the other with a reducing solution, and the electromotive force of the cell was measured. It appears that the differences between the electromotive forces of any two oxidising agents is always the same. For instance, a solution of chlorine in potassium chloride was placed in the one vessel, and one of the following reducing agents in the other, $SnCl_2$, KOH, Na_2S, hydroxylamine and KOH, etc., etc. Certain electromotive forces were obtained. Substituting bichrome as the oxidising agent, another set is found. The differences between the electromotive forces due to the two oxidising agents is always the same, no matter what the reducing agent is. In this particular case the mean difference is 0·603 volts; and the greatest deviations from the mean are 0·601 and 0·607 volts. The electromotive force is independent of the concentration, and of the nature of the electrolytes, so long as they are not attacked.

G. J. Burch and **V. H. Veley** (*Phil. Trans.*, clxxxii. 319) have found that the electromotive force of cells containing nitric acid is very small, provided nitrous acid be destroyed by urea as soon as it is formed. The high potential of such cells is due entirely to the nitrous acid.

T. S. Murray (*Chem. Soc.*, lxi. 10) has investigated the products of electrolysis of potassium acetate, and finds the chief reaction to be that of Kolbe, viz., $2CH_3CO_2 = C_2H_6 + 2CO_2$. At the same time in dilute solutions the ion decomposes to some extent as follows:—

$$2CH_3CO_2 + H_2O = CH_3CO_2H + O.$$

W. H. Perkin, sen., has continued his laborious investigations on magnetic rotation (*Chem. Soc.*, lxi. 800). His object now is to determine whether acetyl derivatives contain the carbonyl group, CO, or the grouping $-CH{=}C.OH{=}CH-$. The magnetic rotation of a great many derivatives of this kind shows that in most cases the substance contains the ketonic group, CO, but that in certain cases the hydroxyl group is also present, owing to isomeric change.

Affinity and equilibrium.

Are all chemical reactions reversible? **Termann** and **Nernst** (*Zeitschr. Phys. Chem.*, ix. 1) have experimented with metals in presence of acids with a view of partially answering this question.

For example, they sealed up in a tube some zinc turnings along with certain quantities of zinc sulphate and sulphuric acid, and measured the pressure at which evolution of hydrogen ceased, *i.e.*, at which the action of the hydrogen on the zinc sulphate was such as to balance the action of the acid on the zinc. To take one instance, a solution contained 0·94 gram of nickel and 0·07 gram nickel sulphate per litre of water; the pressure rose to 7·5 atmospheres. With 1·52 grams of sulphuric acid and 0·50 gram sulphate, the pressure rose to 42 atmospheres, before action ceased. But experiments in the opposite direction, viz., to precipitate such a metal as copper by hydrogen at a high pressure, that is, when a comparatively great mass of hydrogen is present, were fruitless. The authors regard their experiments as merely preliminary.

H. le Chatelier has an important paper in the *Zeitschr. Phys. Chem.*, ix. 336, on the *equilibrium of systems with unequal pressures.* He imagines a cylinder with a piston not fitting tightly, filled with a solid in fragments, the interstices being filled with a liquid which can escape when the piston is pressed into the cylinder. The solid is under a pressure p, in contact with a vapour or liquid under the pressure p'. Let V and V′ be the volumes of the substance in the two states—the temperature T is the same for both—the system is supposed to be in equilibrium, and the variations of pressure and temperature dp and dp' and $d\mathrm{T}$ are to be found which the system can stand, without destroying equilibrium. This condition is fulfilled, if it is supposed that the energy of chemical change is zero, when the pressures and temperatures of the system change, without any chemical change accompanying them. In this way the relation $\mathrm{L}dt/t+\Sigma\mathrm{N}dp/p=0$ is found, where t is the absolute temperature of the system, p the pressure in each element, and L the latent heat of the reaction (bearing in mind that the initial and final pressures are not the same), and N the different latent work of each element of the system, the expression for which is Λpv, where v stands for change of volume. An example is given in the lowering of the melting-point of ice by pressure. Here we have a mixture of snow under the pressure p and of water under the pressure p' at the same temperature; and the equation is $216dt + 19{\cdot}65dp - 18dp' = 0$. The unit of length is here the centimeter, that of mass the kilogram, and dt signifies the change of melting-point. If p be made equal to p' then Thompson's formula is reproduced, and the melting-point is lowered by 0·0075° for a rise of pressure of one kilogram per square centimeter. But if dp' is made equal to 0 without dp equalling 0,

then the melting-point is lowered by 0·091° for each kilogram; that is, the change is ten times greater. The same equation is applied to ice in presence of its own vapour, and to the solubility of ice in some solvent such as salt or glycerine.

These considerations have a very important bearing on many natural phenomena. For example, if finely divided ice or snow is in contact with water or some solvent, and submitted to pressure, the water or the solvent, when it is pressed in contact with ice, will no longer be in equilibrium when it enters the empty interstices; hence ice will be formed there. The formation of ice will progress until the water can circulate no longer, that is, until the fragments of ice are compressed into a solid block. A similar explanation accounts for the formation of marble; and the author has indeed succeeded in producing marble by compressing fragments of calcium carbonate with water. (*See* also *Comptes Rendus*, cxiv. 62.)

J. A. Harker has investigated the partition of hydrogen between chlorine and oxygen, when mixtures of all three gases are exploded together. (*Zeitschr. Phys. Chem.*, ix. 673.) He has found that the ratio between the products of explosion is such that the product of the number of molecules of hydrogen chloride and oxygen, divided by the product of the number of molecules of water-vapour and chlorine, is constant, and equals 23; or in other words, Guldberg and Waage's law holds for mixtures of hydrogen, chlorine, and oxygen.

Paul Henry gives an account of his experiments on the action of bases and acids on lactones, in converting them into acids. (*Zeitschr. Phys. Chem.*, x. 96.) It will be remembered that a lactone is a compound of the nature of an anhydride in which water is given up by a substance, at once acid and alcohol; it is in fact an ethereal salt in which both alcohol radical and acid group are present in the same compound. On treatment with a base, it is converted into a salt of a hydroxy-acid. Different bases have different powers of effecting the change, and Henry shows that their action is proportional to the basic character of the reacting body. He also has proved that the influence of acids, which cause a similar change, is proportional to their coefficients of affinity.

It has long been known that nitric acid, in acting on zinc, liberates oxides of nitrogen, their nature depending on the concentration of the acid, and on the temperature. **C. Montemartini** (*Gazz. Chim. Ital.*, xxii. 1) shows that neither of the usual type of equations is correct. As an example of the first may be given:—$2HNO_3 + 6H = 2NO + 4H_2O$, where hydrogen in the

nascent state is supposed to remove oxygen from nitric acid, converting it into nitric oxide; the second explanation is, that the zinc itself removes oxygen from the nitric acid forming zinc oxide, which then dissolves in the excess of acid. But in neither case is there enough zinc dissolved to correspond to the amount of nitric oxide formed. The author believes that the nitric acid is reduced to nitrous acid, and that the nitrous acid then reacts with water to produce lower oxides of nitrogen. All metals can be divided into three groups, viz., those which yield only nitrous acid, NO, N_2O_3, and NO_2; those which yield in addition N_2O, HNO, N_2, and NH_3; and those which also yield hydrogen. Metals of the first group decompose water, either not at all, or only at a very high temperature; those of the second at a less high temperature; and those of the third at the ordinary temperature. It is with the second, and especially with the first group, that water takes part in the reaction.

A. Colefax (*Chem. Soc.*, lxi. 176) has submitted the decomposition of thiosulphuric acid to careful study. He finds that the stronger the solution, the further the decomposition of the thiosulphuric acid before a limit is attained; which limit is increased by the presence of free acid, and more by HCl than by H_2SO_4.

The products formed on exploding ethylene with oxygen have been studied by **B. Lean** and **W. A. Bone** (*Chem. Soc.*, lxi. 873). When fired with its own volume of oxygen, carbon monoxide and hydrogen are produced, as previously found by Dalton. With less than its own volume of oxygen, methane is formed, and it is suggested that it is due to decomposition of the excess of ethylene into methane and carbon. Unsaturated hydrocarbons are also formed, possibly by the action of the nascent hydrogen on the nascent carbon.

Dissociation.

It is well known that many gases dissociate when heated. **J. T. Cundall** (*Chem. Soc.*, lx. 1076) has for the first time investigated the dissociation of a liquid on dilution, which corresponds to the rarefaction of a gas; and also on raising its temperature. The liquid examined was nitric peroxide, and the diluent was chloroform. The amount of dissociation was measured by comparing the colour-change on decomposition of N_2O_4 into NO_2. Cundall finds the amount of dissociation to be small at first, but to increase rapidly on dilution; and rise of temperature also considerably increases the extent of the dissociation. In a subsequent number of the same journal (lxi. 242) **W. Ostwald** comments on Cundall's work, and points out

that the law of dissociation in the gaseous state is obeyed by this solution. The equation $x \,/\, (1 - x) = Kv^{-}$(where x is the amount of dissociated and $1 - x$ the amount of undissociated peroxide; v the volume of unit mass, and K, a constant depending chiefly on the temperature). From Cundall's observations, K is a constant, and liquid nitric peroxide obeys the gaseous laws of dissociation. But the extent of dissociation in the liquid state is very much less advanced, where the volume occupied by an equal number of molecules is the same as in the gaseous state.

G. Bodlander (*Zeitschr. Phys. Chem.*, ix. 730) has investigated the behaviour of a solution of silver chloride in ammonia, first as regards the formula of the compound formed. It is thrown down by alcohol, in which it is insoluble; and its formula is $2AgCl.3NH_3$. Next it gives the usual silver reactions, which proves that it is ionised on solution. This view is confirmed by the depression of the freezing-point of its aqueous solution, and also by its electrical conductivity, as well as by the fact that on addition of ammonium chloride or silver nitrate to its solution in water its solubility is reduced. It appears, therefore, to undergo no dissociation, except of an electrolytic nature, on solution in water.

INORGANIC CHEMISTRY.

BY HAROLD PICTON, B.Sc.

THE present era of chemical discovery seems to be specially one for upsetting all our common notions about what we thought everyday facts. The reactions occurring in the simplest preparations of gases are continually in dispute, the plainest phenomena of solution have become mysterious, while substances with the most powerful tendency to combine prove, on careful purification, to be incapable of combining at all. From our childhood we have heard of nitrogen as the most inert of gases, as neither "supporting combustion" nor being itself "combustible," yet lately we have had Mr. Crookes showing to the Royal Society a flame of nitrogen burning in air, blowing the flame out and re-lighting it with a taper. We once thought that chlorine and bromine were "monovalent," now the difficulty is to know what valency they have *not*. We used to be taught that phosphorous oxide (P_2O_3) was an amorphous powder which combined with great energy with water. We now learn that phosphorous oxide

(P_4O_6) forms long, radiating, feathery crystals, and only dissolves in water with extreme slowness. In this state of the science it behoves anyone to wear his ideas in such a way that they may be easily cast off, and he will have to watch the fashion pretty closely if he is to be in touch with the times.

In the following pages some of this revolutionising process may be watched, and the reader may specially note the work on double halides, the action of carbonic oxide on iron and manganese, combustions in nitric oxide, phosphorous oxide, the combustion of electrolytic gases, the constitution of the persulphates, combustion of nitrogen, and chemistry of flames.

Halogens and halides.

Chlorine and its derivatives.—The reaction which occurs in the ordinary preparation of chlorine from manganese dioxide and hydrochloric acid is still in dispute. Vernon's investigation led him, in opposition to Pickering, to the belief that manganese tetrachloride forms an intermediate stage in the reaction. ("Year-Book" for 1891, p. 158.) **Pickering** now disputes Vernon's evidence. (*Phil. Mag.* [5], xxxiii. 284.) He points out that it is impossible to recover more than 51·2 per cent. of the dioxide from the chloride by decomposing with water, while if the chloride Mn_2Cl_6 were present the exact yield should be 50 per cent. He holds, therefore, that this chloride is formed. The controversy serves, like many others, to show how imperfect is our knowledge about most of the everyday facts of chemistry.

The action of magnesium on chlorides has been exhaustively studied by **K. Seubert** and **A. Schmidt**. The action of the metal on aqueous solutions of the chlorides, either neutral, acid, or ammoniacal, was investigated, as also the action on the anhydrous chloride. The solutions employed contained about 1 per cent. of the base. The tendency in the case of the *acid* solutions would, of course, be to effect reduction of the dissolved substance. Some of the results of the investigation are given below.

In Family I. of the Periodic Table, Group A, it is found, as might be expected, that aqueous solutions of the chlorides of the alkalis are not affected under any conditions. The anhydrous chlorides, however, are at a red heat, and especially in presence of hydrogen, reduced to metal. This, therefore, affords a new method for the preparation of metallic lithium, sodium, and potassium.

In Group B the chlorides of copper, silver and gold, are readily reduced to metal both in the dry and wet state. From neutral aqueous cupric chloride, however, cuprous oxide is precipitated.

Family II., Group A. The chlorides of calcium, strontium, and barium are not decomposed by magnesium in aqueous solution; the anhydrous chlorides, at a red heat and in a stream of hydrogen, are reduced to the corresponding metal, and the more readily the lower the atomic weight of the metal. This affords a new method of preparing the alkaline earth metals. Group B. Zinc and cadmium chlorides in acid solution are reduced to the metallic state. Mercuric chloride in neutral and acid solution is first reduced to mercurous chloride and then to the metal. The anhydrous chlorides all yield the metal on heating with magnesium.

Family III. Anhydrous boron chloride yields boron with formation of magnesium boride (as previously known). Aluminium chloride heated with magnesium in neutral solution precipitates the hydroxide. At a red heat it is reduced to metal (a new method for the preparation of aluminium).

Family IV., Group A. The chlorides of carbon and silicon are reduced to the corresponding elements. Group B. Both chlorides of tin are reduced to metal in acid solution. Lead chloride invariably gives the metal. Neutral stannic chloride yields stannic acid.

Family V. The chlorides of phosphorus, arsenic, antimony and bismuth are reduced to the corresponding elements at a red heat. In acid solutions the chlorides of arsenic and antimony give the element and also its hydroxide. Bismuth chloride yields only the metal.

Family VI., Group A. The anhydrous chlorides of chromium, molybdenum, tungsten and uranium are reduced to metal at a red heat. Group B. Sulphur chloride yields sulphur on heating with magnesium.

Family VII. Manganese chloride, as already shown by Troost, is at a red heat reduced to metal.

Family VIII. Neutral or ammoniacal solutions of cobalt and nickel precipitate the lower hydroxides. Iron chloride in neutral solution behaves similarly. In acid solutions iron and cobalt yield metal, but nickel chloride is unattacked. Platinic chloride is always reduced to metal, and all these chlorides are reduced at a red heat. (*Annalen*, cclxvii. 218.) These researches complement those of Winkler on the reduction of oxides by magnesium, with which they should be compared. ("Year-Book" for 1891, p. 162.)

The action of light on silver chloride is continually the subject of research, and is now once more dealt with by **H. Brereton Baker.** Ever since the time of Scheele it has been known that chlorine

is evolved on exposure of silver chloride to light. According to V. Bibia, the loss of weight of the silver chloride is, however, almost inappreciable. (But compare Hitchcock, "Year-Book" for 1891, p. 161.) The statement of V. Bibia made it seem probable that some combination occurred to neutralise the loss. A series of careful experiments was made by Baker, in which he exposed dry silver chloride to light in a closed flask filled with oxygen of about 130 cc. capacity, absorbed the chlorine by copper gauze inserted in the stopper, and determined the chlorine given off by the gain in weight of the gauze. To determine the oxygen, if any, absorbed, the flask was connected with a bulb dipping under water and then opened. Water rushed into the bulb, proving absorption of oxygen, and the weight of water in the bulb afforded an accurate clue to the amount of the absorbed oxygen. The provisional formula suggested is $Ag_2\,Cl\,O$. On exposing the chloride to light under pure carbon tetrachloride its colour remained unchanged. (*Jour. Chem. Soc.*, lxi. 728.)

These results seem to prove pretty conclusively that the product of the action of light on dry silver chloride in presence of oxygen is an oxychloride. On the other hand, Richardson held ("Year-Book" for 1891, p. 161) that silver chloride exposed to light under water in presence of air darkened without any absorption of oxygen.

Halides of boron, silicon, and carbon.—**A. Besson** continues his work on the halides, and has investigated the compounds formed by ammonia with boron bromide and iodide.

With boron bromide ammonia reacts with great evolution of heat and some formation of boron nitride. To avert this decomposition both substances must be well cooled. The bromide is dissolved in carbon tetrachloride, which is afterwards volatilised by a current of warm air. The white, amorphous solid is $BBr_3, 4NH_3$. Heated in dry hydrogen it decomposes into boron nitride and ammonium bromide.

In a similar way boron iodide yields $BI_3\,5NH_3$, and this in a current of dry ammonia absorbs the gas, yielding a liquid product which is very unstable and seems to be $BI_3.\ 15NH_3$. (*Comptes Rendus*, cxiv. 542.)

Silicon thiochloride, $SiSCl_2$, is prepared by **Besson** by passing a current of chlorine saturated with vapour of sulphur dichloride over crystalline silicon heated to bright redness. The liquid product contains the thiochloride, which crystallises in white needles. It reacts violently with water, forming sulphuretted hydrogen, hydrochloric acid, and silica. (*Comptes Rendus*, cxiii. 1040.)

The action of bromine on chloroform has also been studied by

Besson. Bromine and chloroform are heated together in strong sealed tubes, the temperature rising finally to 275°. The three chlorobromides indicated by theory are thus obtained, viz., $CCl_3\ Br$, a liquid crystallising about − 21°, $CCl_2\ Br_2$, a solid crystallising in fine needles which melt at 22°, and $CCl\ Br_3$, crystallising in transparent plates which melt at 55°. The compound $CH\ Br_2\ Cl$ is obtained at lower temperatures. Further action of bromine on this seems to form CBr_4. (*Comptes Rendus*, cxiv. 222.)

Moissan has already shown that carbon tetraiodide may be readily obtained by the action of boron triiodide on carbon tetrachloride ("Year-Book" for 1891, p. 159). On exposure, *in vacuo*, to sunlight this substance decomposes into iodine and yellow glistening needles of C_2I_4. The same decomposition occurs slowly in diffused daylight. To obtain this iodide in large quantities the best plan is to reduce the higher iodide by powdered silver. Hydrogen does not act on the new compound even at 200°. (*Comptes Rendus*, cxv. 152.)

Double Halides.—**Remsen** enunciates a general law with regard to the composition of double halides. This is that "when a halogen salt of any element combines with a halogen salt of an alkali metal to form a double salt, the number of molecules of the alkali salt which are added to one molecule of the other halogen salt is never greater, and is generally less, than the number of halogen atoms contained in the latter." Thus two potassium stannochlorides are described by **G. M. Richardson** (*Amer. Chem Jour.*, xiv. 89), viz., $SnCl_2.\ KCl$ and $SnCl_2.\ 2KCl$. In the latter compound we see that the number of molecules of potassium chloride is *equal* to the number of atoms of chlorine in the stannous chloride.

Although a large number of double halides conform to this statement, it must be said that the exceptions are too numerous, even when we accept Remsen's qualifications, to allow of its being erected into a general law. As examples, it will suffice here to mention the following :—

$$CdCl_2.\ 4KCl,\ \ CdBr_2.\ 4KBr,\ \ KF.\ 2HF,\ \ KF.\ 3HF,\ \ PbCl_1.\ 9NaCl,\ \ PbI_2.\ 4KI.$$

There are many others. (Compare Wurtz, *The Atomic Theory*, p. 251, also Armstrong on "Residual affinity," and on Valency, *Nature*, xxxvii. 303.)

Oxygen and Oxides.

Action of carbonic oxide on iron and manganese :—Metals obtained from their amalgams by distillation at low temperatures

(250° — 280°) have been shown to be peculiarly active in their properties. (Compare Macquenne on the formation of metallic nitrides, p. 203.) **Guntz** has made use of this observation in his experiments on the action of carbonic oxide on iron and manganese. Iron, prepared as above described, at a dull red heat absorbs carbonic oxide rapidly. Carbon is deposited, ferrous oxide (FeO) formed, while some carbon dioxide is formed by the reduction of the ferrous oxide by carbonic oxide.

Manganese, similarlyobtained, reacts very rapidly at 400°. Manganese oxide, MnO, is formed and carbon deposited. No carbon dioxide is formed, for, as shown by Moissan, manganous oxide is not reduced by carbonic oxide (*see* also next section).

With both metals at very high temperatures the reverse reactions occur, the first reaction evolving less and less heat as the temperature at which it occurs rises.

$$\text{(i)} \quad Fe + CO = FeO + C$$
$$\text{(ii)} \quad FeO + C = Fe + CO.$$

(*Comptes Rendus*, cxiv. 115.)

The above constitutes the first part of Guntz's work. In continuation of his experiments he acts on the active iron obtained as before, with carbonic oxide at the *ordinary temperature.* A gas is obtained very rich in iron carbonyl. (Compare Mond and Langer, "Year-Book" for 1891, p. 166.) On heating to 150°—160° gas is absorbed, and the previously-described reaction occurs. (Equation i.) On heating rapidly to 300° carbon dioxide is found mixed with the carbonic oxide owing to partial reduction of the ferrous oxide. The author points out the bearing of these experiments on the theory of the blast furnace. In one zone the iron is oxidised by the carbonic oxide and carbon is deposited, in another it is reduced and yields carbon dioxide, while in the hottest zone the iron unites with the carbon. (*Bull. Soc. Chim.* [3], vii. 278.)

Guntz also mentions that a deposit of iron oxide is noticed at Nancy on gas jets long exposed to the flame. This deposit must be formed from iron carbonyl in the gas, this substance being formed presumably during the purification of the coal gas by means of ferric hydrate. (*Ibid.* 281.)

Carbon dioxide.—Continuing his work on manganese **Guntz** shows that in carbon dioxide it reacts as follows:—

$$\text{(i)} \quad 2Mn + CO_2 = 2MnO + C + 46{\cdot}3 \text{ Cal.}$$

while we have also $Mn + CO = MnO + C + 33{\cdot}3$ Cal. In view

of these reactions the question arises, Why does carbon reduce manganous oxides at a white heat? and Guntz suggests that at that temperature the second reaction becomes exothermic.

A. d'Arsonval finds that liquefied carbon dioxide is a powerful antiseptic. At high temperatures it can displace both organic and mineral acids. Thus uric acid is deposited from urine when heated with CO_2 at 40 atmospheres, while at the same pressure hydriodic and hydrobromic acids are liberated from solutions of potassium iodide and bromide. (*Comptes Rendus Soc. Biol.*, 1891, 320.)

Silica.—**Scheurer-Kestner** shows that in the manufacture of glass from alkaline sulphate, carbon, and silica, the probable reaction is—

$$3Na_2SO_4 + 6SiO_2 + 5C = 3S + 4CO_2 + CO + 3\,(Na_2O.\,2SiO_2)$$

No sulphurous acid is evolved. (*Comptes Rendus*, cxiv. 117.)

E. Cramer has examined the volatility of silica (previously proved by Jeffrey). The heat needed is extreme, but in a Deville's furnace 3 grams of silica lose in two hours about 40 % of their weight. This is at a temperature at which platinum boils. (*Zeitsch. f. Angew. Chem.*, 1892, 484.)

Nitric oxide.—Interesting experiments have been made by **Sebatier** and **Senderens** on combustions in nitric oxide. Metals which remain unchanged in air do not seem to be oxidised by nitric oxide. Thus silver, platinum, mercury, and aluminium are not acted upon by the gas at high temperatures. In their first experiments the authors found that copper, iron, cadmium, and zinc become superficially coated with oxide at a dull red heat. Lead is more readily attacked. In these experiments the metals were used in a massive form.

Finely-divided metals obtained by reduction of the oxides behave differently. At temperatures at which nitric oxide is quite stable many of them are converted into oxides, usually different from those formed in air. Thus, reduced *nickel* glows at 200° and is converted into the yellow-green monoxide. *Iron* burns at 200° and yields the grey monoxide. Copper oxidises at 200° and is converted in cuprous oxide, Cu_2O. Spongy palladium, saturated with hydrogen, has in the cold no appreciable action. At 200° it burns with formation of water and ammonia, but the metal is not oxidised.

Metallic oxides will also burn in nitric oxide. Thus Tungsten dioxide (WO_2) glows below 500° and yields the sesquioxide W_2O_3. In air the product would be the trioxide, WO_3. Uranium dioxide, UrO_2, yields Ur_2O_5. In air the product would be Ur_3O_8.

Molybdenum sesquioxide, Mo_2O_3, yields the dioxide MoO_2, while in air the product would be MoO_3. Titanium sesquioxide, Ti_2O_3, without glowing, yields TiO_3. Stannous oxide, SnO, yields stannic oxide, SnO_2. Cuprous oxide remains unchanged. Vanadium sesquioxide, V_2O_3, does not change below 500°. In air it readily yields VO_2. (*Comptes Rendus*, cxiv. 1429.)

The authors also show that on higher oxides nitric oxide can act as a reducing agent. For thermo-chemical reasons we should not expect the oxides of mercury, copper, iron, or zinc to be reduced. But silver oxide (Ag_2O), chromium trioxide (CrO_3), and lead dioxide (PbO_2) are reduced. The reduction begins in the case of chromium at the ordinary temperature, with silver at 170° and with lead at 315°. Manganese dioxide is reduced at 400°.

Nitric oxide reacts with the following oxides in presence of water to form nitrites, viz., BaO_2, PbO_2, MnO_2, Ag_2O. (*Comptes Rendus*, cxiv. 1476.)

Sebatier and Senderens have also examined the action of nitric peroxide, NO_2, on oxides and metals. The oxides, when acted on, yield higher oxides. Thus MnO is converted into Mn_2O_3, while WO_2 yields WO_3 at about 300°. Some metals are oxidised, as, for instance, zinc, lead, iron, while others combine directly with the nitric peroxide to form what seems to be a new and interesting series of compounds. Thus reduced copper yields Cu_2NO_2, a substance of a chestnut-brown colour. It reacts with water with production of nitric oxide and copper nitrate, while some metallic copper is left. Heated in nitrogen the substance loses nitric peroxide. Cobalt forms a similar compound, $CoNO_2$. These substances are nitro compounds, not nitrites; that is to say, their probable constitution is $M-N{\overset{\displaystyle O}{\diagup\!\!\diagup}}$ not $M-O-N=O$.

(*Comptes Rendus*, cxv. 236.)

F. **Emich** has made a number of observations on nitric oxide. He finds that it is not wholly decomposed by the highest temperature of a Fletcher's tube oven, but at the very high temperatures obtained by electrical ignition of platinum nets it is completely resolved into nitrogen and oxygen. He also states that nitric oxide and oxygen react even after the most careful drying over phosphorous pentoxide. Continuing the investigations of others he finds that nitric oxide reacts with potash slowly, especially when heated (125°), according to the equation $6NO + 4KOH = N_2 + 4KNO_2 + 2H_2O$. (*Monatsh.*, xiii. 7886, 90.)

Phosphorous oxide.—An allusion to the important work of **Thorpe** and **Tutton** on this oxide has been made in the introductory note. The first section of their work was published in 1890 (*Jour. Chem. Soc.*, lvii. 545), while it was completed at the close of last year. (*Vide* "Year-Book" for 1891, p. 176.) During their work on phosphorous tetroxide (P_2O_4) the authors had noticed the occurrence of a sublimate of long feathery crystals volatile in a current of nitrogen or carbon dioxide below 100°. To obtain these crystals in quantity a fairly rapid current of air is passed over phosphorus contained in a combustion tube, the products passed through a tube kept by a jacket at a temperature of about 50°, phosphorus pentoxide filtered off by a plug of glass wool and the above-mentioned substance condensed in a U tube surrounded by a freezing mixture. This crystalline product melts at 22·5° and boils at 173·1°. Analysis shows it to be phosphorous oxide. The vapour density, determined by Hofmann's method, was found to agree closely with the formula P_4O_6. Its constitution is thus analogous to that of arsenious and antimonious oxides as ascertained by Victor Meyer. The solution in benzene gave, by Raoult's method, the same result. The oxide is stable up to 200°. At 440° it is wholly decomposed according to the equation $2P_4O_6 = 3P_2O_4 + P_2$. The atomic volume of the phosphorus in the oxide (assuming the oxygen atoms to be singly linked) is found to be 20·9, being identical with that observed with phosphorus in the free state. Other physical properties were also examined. The action of water on either the solid or liquid oxide is, quite contrary to previous descriptions, exceedingly slow. After several days hardly any change is observed, but on long standing the oxide completely dissolves:—

$$P_4O_6 + 6H_2O = 4H_3PO_3.$$

When the water is heated the reaction becomes very energetic. Alkalis act upon the oxide in a manner similar to water. With absolute alcohol the oxide reacts very energetically, the product being diethylphosphorous acid, $P\left\langle\begin{matrix}OC_3H_5\\OC_2H_5\\OH\end{matrix}\right.$ The oxide is spontaneously oxidised on exposure to air, no formation of ozone being observed. The authors consider this supports the view that the formation of ozone during the glow of phosphorus is due to the dissociation of the oxygen molecule, as under:—

$$P_2 + 3O_2 = P_2O_5 + O$$
$$O + O_2 = O_3$$

while with the phosphorous oxide we have :—

$$P_4O_6 + 2O_2 = 2P_2O_5$$

in which no dissociation need occur. (*Jour. Chem. Soc.*, lvii. 545.) In their second paper the authors have further examined the properties of the oxide. Light acts upon the oxide as ordinarily obtained, a separation of red phosphorus occurring. Certain specimens, however, were much more slowly acted on, while one is mentioned which after twelve months' exposure remained unacted on. Bromine reacts with the oxide with production of phosphorus pentabromide, while the final reaction produces phosphorus oxybromide and metaphosphoryl bromide :—

$$P_4O_6 + 4Br_2 = 2PO\,Br_3 + 2PO_2Br.$$

This reaction is similar to that occurring with chlorine. Iodine only acts very slowly and with production of P_2I_4. The action of sulphur is particularly interesting. The two substances are heated together in an atmosphere of carbon dioxide, and at 160° a very violent reaction occurs and feathery crystals of the new compound, phosphorus sulphoxide, $P_4O_6S_4$, are produced. This is a white solid melting at 102° and boiling at 295°. The vapour density accords with the formula, $P_4O_6S_4$; the substance is therefore not a thio-derivation of the pentoxide ($P_2O_3S_2$), but an additional compound of the phosphorous oxide with sulphur. It reacts with water as follows :—

$$P_4O_6S_4 + 6H_2O = 4HPO_3 + 4H_2S.$$

Ammonia acts energetically upon the melted oxide, apparently forming the hitherto unknown diamide of phosphorous acid :—

$$OH{\cdot}P\left\langle\begin{matrix}NH_2\\NH_2\end{matrix}\right.$$

This research is of peculiar interest, as showing that exact investigation of the properties of substances most familiar to the chemist still yields wide tracts of undiscovered country to the explorer. (*Jour. Chem. Soc.*, lix. 1019.)

Action of sulphur on metallic oxides.—**J. B. Senderens** has investigated the action of sulphur on metallic oxides and salts. His results can be arranged under three heads. (1) On boiling the solution of an alkali or an alkaline earth with sulphur the following reaction occurs :—

$$3M''O + nS + H_2O = 2M''S_{n-2} + S_2O_3M'' + H_2O$$

(2) In the case of other metallic oxides, more variety displays

itself. When mercuric oxide is rubbed with sulphur it ignites with formation of mercuric sulphide, sulphate, and sulphur dioxide. Similar results are obtained with chromium trioxide. Water stops the reaction in the cold.

Silver oxide boiled with sulphur in water reacts as follows:—

$$\text{(i.)}\quad 4Ag_2O + 4S = 3Ag_2S + Ag_2SO_4$$
$$\text{(ii.)}\quad 3Ag_2SO_4 + 4S = 3Ag_2S + 4SO_3.$$

Cupric and cuprous oxides act similarly. With the oxides of mercury, lead, bismuth, nickel, cadmium, the reaction only goes through the first stage, however long the boiling be continued. The oxides of zinc, iron, and tin are not attacked.

(3) With salts the following results are obtained:—Sulphates, nitrates, and chlorides of the alkalis are not attacked by boiling with sulphur. Acetates are slowly attacked. Alkaline carbonates give polysulphides, thiosulphate, and carbon dioxide. But the reverse reaction goes more easily:—

$$K_2S_n + H_2CO_3 = K_2CO_3 + H_2S + S_{n-1}$$

The carbonates of the other metals act like the oxides towards sulphur.

Carbonates and silicates of the alkalis and the alkaline earths are decomposed, and ordinary finely powdered glass yields on boiling with water and sulphur sulphuretted hydrogen and thiosulphate.

(4) Sulphur has no action on water, the observations of others to the contrary being due to action on the glass vessels used. (*Bull. Soc. Chim.* [3], vi. 800.)

Electrolytic gases.—**Victor Meyer**, in conjunction with **Krause**, **Freyer**, and **Askenasy**, has made an interesting series of experiments on the combination of electrolytic gases. Combination may occur slowly at low temperatures, or rapidly and finally with explosion at high ones. But the rate of combination is found to depend very greatly upon the surfaces with which the mixture is in contact. Thus when moist electrolytic gases are heated in glass vessels over mercury at 305° for 1—2 weeks the combination occurring is almost complete. In absence of mercury, however, the rate of the reaction is much modified, and not much water is formed till a temperature of about 518° is reached. A bath of boiling zinc chloride (730°) causes explosive combination.

It is found that bulbs containing pure dry or moist electrolytic gas can be sealed without danger when the capillary tube does not exceed $\frac{1}{2}$ to $\frac{1}{3}$ mm. in internal diameter. In the case of

the moist gas a flame is observed to pass along the capillary, but it goes out before reaching the bulb (being cooled down by the surrounding glass).

Endeavours to obtain definite quantitative relations between the rates of combination at different temperatures have at present proved futile. This is owing to the extraordinary amount of influence exercised by the surfaces with which the gases are in contact. Thus, on using bulbs the inner surfaces of which are coated with silver, 70 per cent. of the electrolytic gases combine in two hours at so low a temperature as 183°, while complete combination occurs at 218°. Owing to slight differences in their surface action it is impossible to get glass bulbs that are comparable, and no constant results have as yet been obtained. The experiments are still in progress. (*Annalen*, cclxiv. 85; *Berichte*, xxiv. 4233; *Berichte*, xxv. 622; *Annalen*, cclxix. 49.)

Sulphur and its derivatives.

Action of sulphuretted hydrogen on metallic compounds.—As already stated in the introductory note, we are now becoming accustomed to find that reactions between pure substances will not take place. Veley has shown that a mixture of *dry* sulphuretted hydrogen with *dry* carbon disulphide does not act on titanium sesquioxide (Ti_2O_3), though under ordinary circumstances titanium sulphide would be found. **R. E. Hughes** has extended these observations, and finds that *dry* sulphuretted hydrogen has no action on magnesia (MgO) between 15° and 40° C. With ferric oxide the absence of action is not so complete. Lead acetate paper, however, which affords the most delicate test for sulphuretted hydrogen, being blackened by the smallest traces of the gas, remains quite white in perfectly dry sulphuretted hydrogen. The presence of the smallest amount of moisture causes immediate blackening. Hughes obtains similar results with the salts of arsenic, zinc, cadmium, bismuth, antimony, silver, copper, mercury, and cobalt. (*Phil. Mag.* [5], xxxiii. 471.)

Hughes and Wilson have also shown that dry hydrochloric acid has practically no action on potassium carbonate or witherite. (*Phil. Mag.* [5], xxxiv. 117.)

Sulphur oxides.—**Moritz Traube** has repeated his experiments on "sulphur holoxide" ("Year-Book" for 1891, p. 169), and reasserts his belief in the existence of the oxide SO_4, upon which doubts had been cast by Berthelot and by Marshall. He considers his results reconcilable with theirs on the supposition that, in presence of alkali, SO_4 unites with sulphuric acid, yielding $H_2S_2O_8$. (*Berichte*, xxv. 95.)

The persulphates.—From experiments on the electrical con-

ductivity of its solution, Marshall concluded that the molecular formula of potassium persulphate was KSO_4. Richard Loewenherz has more recently determined various physical properties of the solution, and arrives at the conclusion that the molecular formula of the salt is probably $K_2S_2O_8$. First of all he takes the depression of the freezing point which gives a molecular weight of 104. Now $K_2S_2O_8 = 270$, and $KSO_4 = 135$. If $K_2S_2O_8$ be supposed to dissociate completely into K, K, S_2O_8, the depression of the freezing point caused by the three ions would, according to the ordinary rules, be treble that caused by the undissociated molecule. If, then, we calculate the molecular weight as if no dissociation had occurred (the method adopted), this would yield the number $\frac{270}{3} = 90$. The depression caused by the molecule $K_2S_2O_8$ may therefore be such as to yield a molecular weight varying between 270 and 90. Similarly the molecule KSO_4 might appear as having any molecular weight between 135 and 67·5. The observed number 104 might thus be obtained with either $K_2S_2O_8$ or KSO_4, and does not decide the question.

The relative proportions of dissociated and undissociated molecules may be deduced from Van't Hoff's formula:—

For $K_2S_2O_8$ $$i = \frac{270}{104} = 2{\cdot}60$$

For KSO_4 $$i = \frac{135}{104} = 1{\cdot}30$$

But i may also be deduced from the electrical conductivity.

A 1 per cent. solution gives $\mu = 92{\cdot}0$. Marshall found $\mu_\infty = 140{\cdot}7$

$$\frac{\mu}{\mu_\infty} = \frac{9{\cdot}20}{140{\cdot}7} = 0{\cdot}65 = x$$

and $i = 1 + (n - 1)x$ where n = number of ions.

Now, for $K_2S_2O_8$ $n = 3$, $i = 2{\cdot}30$, calculated from freezing point 2·60. For KSO_4 $n = 2$, $i = 1{\cdot}65$, calculated from freezing point 1·30. In the first case the difference between the two values of i amounts to 11·5 per cent., in the second to 21·2 per cent. The author therefore concludes that $K_2S_2O_8$ is the more probable formula.

In a redetermination with a 1·5 per cent. solution he obtains the following numbers:—molecular weight calculated from depression = 113.

	From depression.	From mol. conductivity.	Difference.
i for $K_2S_2O_8$	2·39	2·24	7 per cent.
i for KSO_4	1·19	1·62	36 per cent.

(*Chemiker Zeitung*, xvi. 838.)

Nitrogen and compounds containing nitrogen.

Combustion of nitrogen.—To many readers it will seem startling to speak of a flame of burning nitrogen, yet at a very high temperature nitrogen will unite with the oxygen of the air and *burn*. At the Soirée of the Royal Society on June 15 **Crookes** showed the combustion of nitrogen by passing an electric current of 65 volts and 15 amperes, alternating 130 times a second, through the primary of a large induction coil, when an arching flame, consisting chiefly of burning nitrogen, issued from each of the secondary poles, meeting in the centre. The poles when the flame is started can be drawn apart to a distance of 212 mm. The flame is easily blown out by the breath and can be relit by a taper. The spectrum of the flame shows no lines. Its temperature is above the melting point of platinum. During the combustion strong odours of nitrous acid are perceived. Owing to the very high igniting point the flame does not spread, or it would involve the whole atmosphere, and the world would be deluged in a sea of nitric acid. (*Chem. News*, lxv. 301.)

Formation of metallic nitrides.—**Maquenne** has shown that on treating amalgams of barium or strontium with nitrogen at a dull red heat, and finally expelling all mercury at a bright red heat, nitrides of barium and strontium are obtained with the probable formulæ N_2Ba_3, N_2Sr_3. The barium nitride at a dull red heat reacts energetically with carbonic oxide with production of baryta and barium cyanide. Strontium nitride yields under similar circumstances only a trace of cyanide. (*Comptes Rendus*, cxiv. 25, 220.)

V. Lepel has also experimented on the oxidation of nitrogen by the electric spark. He finds that the first product is nitric oxide, which is then converted into nitrogen peroxide (NO_2) by absorption of oxygen. This reacts with water:—

$$3NO_2+2H_2O=2HNO_3+NO.$$

The oxidation reaches a limit when the decomposition of the oxidised products NO and NO_2 by the spark equals their rate of formation. (*An. d. Physik und Chim.*, xlvi. 319.)

Amide and Imide of Sulphuric Acid.—**Wilhelm Traube** has examined the compound first obtained by **Regnault** by the action of ammonia on sulphuryl chloride dissolved in an indifferent solvent (*e.g.*, chloroform). The product when extracted is a syrup which is probably sulphamide, $SO_2(NH_2)_2$, the diamide of sulphuric acid $SO_2(OH)_2$. With some metallic salts this substance yields amorphous precipitates. The aqueous solution treated with

ammoniacal silver nitrate yields the specially interesting silver compound. When this is heated ammonia is evolved and (at a temperature of 170° to 180°) the new compound silver sulphimide, $SO_2{=}NAg$, the silver salt of the imide of sulphuric acid, is formed. It crystallises from acidulated water in long needles. (*Berichte*, xxv. 2472.)

Boron and its derivatives.

Elementary boron.—**Moissan** has published a series of papers on this element. In the first of them he states that no boron has yet been obtained in a state of purity. By whatever metal or metalloid we reduce its oxide this substance forms an impurity in the liberated boron. So, too, when obtained by the method of Berzelius (by the action of potassium on potassium boro-fluoride) the element contains metallic derivatives. In his next paper Moissan says that by reducing boron trioxide (boracic acid) with *insufficient* magnesium, and by a long series of extractions, we obtain amorphous boron containing 98·3 per cent. of the element. The purified boron is a chestnut-brown powder, not melted by the heat of the electric arc and with a very low conductivity. At 700° it burns in air. In oxygen it burns with extreme brilliancy. It reacts with sulphur at 610, with selenium at higher temperatures, while tellurium only combines with it on ignition. Chlorine unites with it at 410°, bromine at 700°, iodine not at all. Nitrogen combines with it slowly at 900°, quickly at about 1230°. Alkali metals do not unite with it, magnesium combines at a dull red heat. Sulphuric acid reacts at 250° with production of SO_2. Hydrofluoric acid only reacts at a dull red heat, hydrochloric acid at a bright red heat. Boron reduces water above a red heat. Nitrous oxide at a dull red heat reacts with it, yielding the nitride BN and the oxide B_2O_3. Nitrogen peroxide, NO_2, does not attack it. Metallic fluorides are rapidly attacked by boron. If boron be dropped into molten potassium chlorate a blinding flash of light occurs. Potassium permanganate is reduced by it in the cold, while the chlorides of palladium, platinum, and gold are reduced to metal. (*Comptes Rendus*, cxiv. 319, 392, 617.)

Boron derivatives.—(*See* also under "Halides," p. 193.) **Moissan** obtains the phosphoiodide, BPI_2, by the action of phosphorus in carbon bisulphide on boron triiodide. By hydrogen this compound is reduced to BPI and thence to the phosphide, BP. (*Comptes Rendus*, cxiii. 624.)

The sulphide, B_2S_3, is prepared by Moissan by acting with sulphur on the iodide above 440°, or by acting on amorphous boron with sulphur vapour at 1200°. The iodide in carbon

bisulphide reacts with sulphur at 60°, forming B_2S_5. (*Comptes Rendus*, cxv. 203, 271.)

A new element.

Indications of a possible new element in an Egyptian mineral have been obtained by **H. Droop Richmond** and **Hussein Off**. A fibrous alum sent to them by Johnson Pasha proved to contain an element giving novel reactions. Among these may be noticed the following:—White precipitate with sulphuretted hydrogen in presence of acetic acid (compare zinc). White precipitate with ammonia, insoluble in excess (difference from zinc, resemblance to beryllium). White precipitate with ammonium oxalate (compare calcium). The element seems to belong to the family beryllium, strontium, calcium, and barium. It also resembles zinc, which occurs in the second division of this family. By precipitating as oxalate, and determining loss on ignition, the atomic weight, if the element be monovalent, was found to be 114, if divalent 228. Now a vacancy occurs in the periodic table in the first division of the above family for an element with atomic weight 225, and the authors are inclined to think that they have found this missing element, just as other elements whose existence Mendeléeff and Newlands predicted have already been discovered. They propose to call the new element *masrium*. (*Jour. Chem. Soc.*, lxi. 491.)

Chemistry of flames.

The interesting work done by Smithells and Ingle on this subject was referred to in the "Year-Book" for 1891, p. 175. **Vivian Lewes** early in 1892 contributed work on this subject. He shows (in harmony with Landolt) that the first constituent of the gas to burn is hydrogen, while the saturated hydrocarbons diminish rapidly, but the unsaturated hydrocarbons very slowly till the luminous zone is reached. He also shows that the proportion of acetylene present in the unsaturated hydrocarbons increases as the gases pass from the interior to the top of the inner non-luminous zone, at which point the acetylene constitutes over 70 per cent. of the unsaturated hydrocarbons present. The gases were drawn off by means of a small platinum tube, 2 m.m. in diameter.

It is heat alone which causes the decomposition of the unsaturated hydrocarbons into acetylene. This the author shows by passing gases, such as ethylene, ethane, methane, through a fine platinum tube heated to 1000°, having first shown that the surface action of the platinum is not important. That ordinary coal gas contains so very small an amount of acetylene the author considers to be due to the comparatively low temperature of the gas within the retorts (700°–800°). Oil gas obtained from Russian

petroleum is shown to contain more acetylene when the distillation is carried on at higher temperatures.

Lewes considers that in a luminous flame the gases rise in the inner zone till, at its apex, at a temperature of about 1000°, some of the hydrocarbons are converted into acetylene, carbonic oxide and hydrogen being also formed. Passing on, the carbonic oxide and hydrogen burn, while the acetylene is decomposed by the heat (1100°–1300° odd), solid carbon being liberated, which is rendered incandescent and burns. According to this theory the whole of the luminosity of a gas flame is dependent upon the formation of acetylene.

The effects of different diluents are also examined. In the destruction of luminosity the specific heat of the diluting gases is found to play an important part, and for this reason carbon dioxide has a powerful effect owing to its high specific heat, by reason of which it abstracts more heat from the flame. But an inert gas also retards the separation of carbon, as was shown by passing mixed gases through heated tubes. The formation of acetylene is also retarded by dilution with inert gases. An active gas, such as oxygen, renders the hydrocarbons non-luminous by burning up before acetylene is formed. It will be obvious that in the case of an ordinary non-luminous Bunsen flame these various effects combine. (*Jour. Chem. Soc.*, lxi. 322; *see* also p. 183.)

Miscellaneous.

Cyanide of arsenic has been prepared by **Moissan** by the action of iodide of cyanogen on finely-powdered arsenic. The cyanide, $As(CN)_3$ forms pale yellow crystals, which are at once decomposed by water: $2\,As(CN)_3 + 3\,H_2O = As_2O_3 + 6\,HCN$. (*Comptes Rendus*, June, 1892.)

A compound of gold and cadmium, AuCd, has been isolated by **Heycock** and **Neville**. Last year they observed that the depression of the freezing point of tin by the simultaneous introduction of gold and cadmium was considerably less than the sum of the effects which each of these metals would produce separately. It was suggested that the difference was due to combination between the gold and cadmium, and this suggestion is now proved correct. The authors now prepare the alloy AuCd by melting excess of cadmium with gold in a vacuum tube. Combination occurs, the gold becoming incandescent. The excess of cadmium is then distilled off. Hot nitric or hydrochloric acids dissolve the cadmium, the gold being left unattacked. (*Jour. Chem. Soc.*, lxi. 914.)

ORGANIC CHEMISTRY.

I.—FATTY COMPOUNDS.

By HAROLD PICTON, B. Sc.

Hydrocarbons.

Behaviour of ethylene on explosion with oxygen.—**B. Lean** and **W. A. Bone** have investigated the reactions occurring when ethylene is exploded with varying volumes of oxygen, with a view to determining the effects of its incomplete combustion. This subject occupied Dalton so long ago as the first decade of this century, but the whole subject of the incomplete combustion of hydrocarbons still forms a little-known country (*see* under "Chemistry of Flames," pages 205, 206). From their results Lean and Bone deduce the following conclusions:—(1) When ethylene is fired with its own volume of oxygen, the final products are carbonic oxide and hydrogen, $C_2H_4 + O_2 = 2\ CO + 2\ H_2$. (This result accords with the work of Dalton, Kersten, and E. von Meyer.) (2) With less than one volume of oxygen methane is found among the products, and the amount formed increases as the proportion of oxygen decreases. Thus 100 vols. ethylene were exploded with 92·04 vols. oxygen. The resultant gases contained 2·52 per cent. of methane. One hundred vols. of ethylene were exploded with 70·44 vols. oxygen. The resultant gases contained 5 96 per cent. of methane. The authors suggest that methane is formed by the decomposition of ethylene by the heat of the main reaction, $C_2H_4 = CH_4 + C$. (3) With less than an equal volume of oxygen carbon is liberated. (4) With less than an equal volume of oxygen unsaturated hydrocarbons are formed, among which acetylene may be detected. The authors suggest that the acetylene is formed by the union of nascent hydrogen with nascent carbon. (*Jour. Chem. Soc.*, lxi. 873.)

It may be remarked that the above work confirms the view that it is the carbon and not the hydrogen of a hydrocarbon which is first attacked by the oxygen. The bearing of the work upon the interesting subject of the chemistry of flames is obvious; but on this point it is well at present to keep an open mind. To quote H. E. Armstrong, it is "unwise at present to infer that the oxidation of the hydrocarbons, or the separation of carbon and also of hydrogen from them, takes place entirely in any one way."

The reader may compare the results obtained by the combustion of ethylene with water-vapour. ("Year-Book" for 1891, p. 176.)

Preparation of acetylene.—**P. Cazeneuve** shows that acetylene may be obtained from bromoform by the action of dry powdered silver. The reaction starts spontaneously, and if the mixture is warmed, becomes very violent. With chloroform the reaction will not occur. Bromoform itself scarcely reacts with sodium. The author previously obtained acetylene from iodoform by a similar method. (*Comptes Rendus*, cxiii. 1,054.)

Maquenne describes a convenient method of preparing the same gas. By heating powdered retort-charcoal with barium amalgam this chemist obtained the barium carbide, BaC_2. Brought into contact with water this compound evolves acetylene.

Maquenne now adopts a much more convenient method for preparing the carbide. This consists in igniting together barium carbonate, magnesium, and carbon. The barium is reduced (*see* "Metallic halides") and combines with the carbon.

$$BaCO_3 + 3Mg + C = BaC_2 + 3MgO.$$

Carbide of barium is unaltered in dry air. It is a grey porous substance, which burns in air when heated to redness, and is also capable of combustion in chlorine, hydrochloric acid, and vapour of sulphur.

Acetylene is readily prepared by allowing water to drop upon this substance.

$$BaC_2 + 2H_2O = Ba(OH)_2 + C_2H_2.$$

The acetylene so obtained is remarkably pure, containing 98 per cent. of C_2H_2. (*Comptes Rendus*, cxiv. 354.)

Nitration of paraffins.—**Konovaloff** succeeds in nitrating some paraffins by the action of dilute nitric acid in sealed tubes. Thus hexane and octane give good yields (50 per cent.) of nitro derivatives at about 130° to 140°. (*Comptes Rendus*, cxiv. 26.)

Halogen derivatives.—The ordinary rule is that if fatty halogen derivatives are further halogenated, the entering halogen atom, where possible, attaches itself to the carbon atom which is already combined with halogen. This rule has exceptions, and some more are pointed out by **Victor Meyer** and **Franz Müller**. Thus $CH_3.CH_2Cl$ on chlorination yields, under ordinary circumstances, $CH_3.CHCl_2$. If, however, iron be present, the symmetrical derivative $CH_2Cl.CH_2Cl$, ethylene chloride, is formed. Under similar conditions propyl bromide yields $CH_3.CHBr.CH_2Br$. Antimony pentachloride converts ethyl chloride, C_2H_5Cl, into ethylene chloride, $CH_2Cl.CH_2Cl$. (*Berichte*, xxiv. 4247.)

Acids, general.

Bromination of fatty acids.—Auwers and Béhal obtained

monochloracetic acid by treatment of a boiling mixture of acetic acid and sulphur with chlorine. **P. Genvresse**, substituting bromine for chlorine, uses a similar method for the bromination of fatty acids. By its means he obtains mono and dibrom-acetic acid, oxymonobrompropionic acid and monobrombutyric acid. (*Bull. Soc. Chim.* [3], vii. 364.)

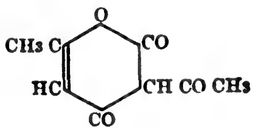
Angelo Simonini has re-examined the action of iodine on the silver salts of fatty acids. He finds that when iodine acts on silver acetate the reaction may be expressed broadly by the equation $2CH_3.CO.OAg + I_2 = 2AgI + CO_2 + CH_3.CO.OCH_3$. With silver caproate an exactly similar reaction occurs, amyl caproate being produced—

$$2AgC_6H_{11}O_2 + I_2 = C_5H_{11}.C_6H_{11}O_2 + CO_2 + 2AgI.$$

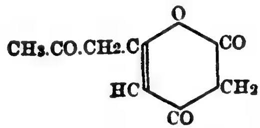
(*Monatsh.*, xiii. 320.)

Acids, special.

Dehydracetic acid.—**Feist** brings forward some objections to Collie's formula for this substance. (*See* "Year-Book" for 1891, p. 182.)

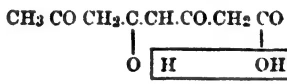


Feist's formula.



Collie's formula.

$CH_3.CO\ CH_2\ CO\ CH_2\ CO.CH_2\ COOH$

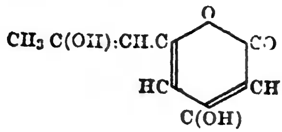


Derivation from tetracetic acid (Collie).

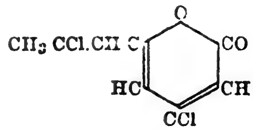
His objections are, on the whole, unimportant. At present either formula proves almost equally suitable to the reactions and formation of dehydracetic acid. Collie's formula is, however, undoubtedly the simpler, and, moreover, Feist's formula is quite unable to explain the formation of a dichloride.

Among Feist's arguments we may note the following. He considers the formation of orcinol (*see* "Year-Book" for 1891) not fully proved. The production of a dichloride, $C_8\ H_6\ O_2\ Cl_2$, would strongly suggest that dehydracetic acid contains two

hydroxyls, as in the tautomeric form of Collie's formula. Feist,



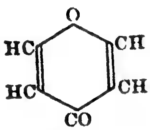
Tautomeric form.



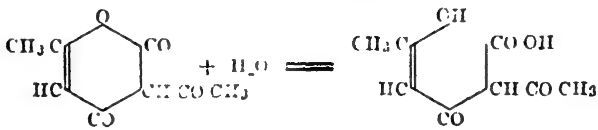
Dichloride (Collie).

however, considers that this substance is not a simple derivative of dehydracetic acid.

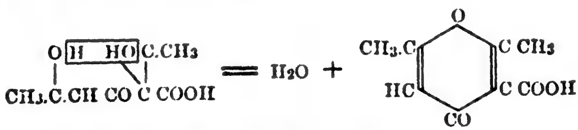
The formation of *aa'*dimethyl pyrone can be explained by either formula, Feist reaching it by way of dimethylpyrone carboxyllic acid and Collie through methylpyroneacetic acid, either of which would yield the above dimethylpyrone by loss of carbon dioxide. Supposing the acid to first take up and then split off water, we have, according to Feist :—



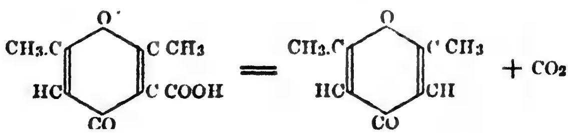
Pyrone.



With loss of water this yields :—



When this loses carbon dioxide we have :—



*aa'*dimethyl pyrone.

According to Collie the reaction may be supposed to run as follows :—

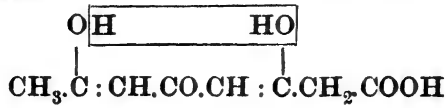
The dehydracetic acid takes up water yielding tetracetic acid, and we then have :—

$$CH_3.CO.CH_2.CO.CH_2.CO.CH_2.COOH$$

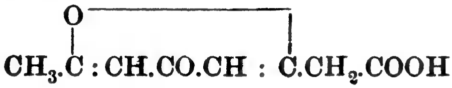
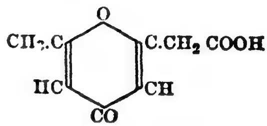
or the tautomeric form

$$CH_3.C(OH) : CH.CO.CH : C(OH).CH_2.COOH$$

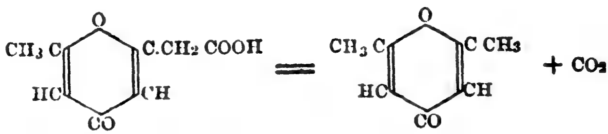
which loses water



giving us :—

 or 

which is dimethylpyronecarboxyllic acid, and by loss of carbon dioxide would yield the same dimethylpyrone.



Much, therefore, depends on whether the intermediate acid isolated by Feist is dimethylpyrone carboxyllic acid or methylpyroneacetic acid.

By the action of phosphoric acid on dehydracetic acid Feist obtains a phosphoric ether in which only one hydroxyl group is attacked, $C_8H_7O_3.H_2PO_4$. This, he considers, suggests that dehydracetic acid acts as a monohydroxylic (not a dihydroxylic) alcohol.

Feist's most weighty argument is that the formation of dehydro-benzoylacetic acid cannot be explained by a process analogous to that suggested by Collie, since in benzoylacetic acid there is no methyl group to be attacked. Feist considers the dehydro-benzoylacetic acid as the strict analogue of dehydracetic acid, but from this view Collie dissents, on the ground of the divergent behaviour of the benzoyl derivative. For instance, with phosphorus pentachloride the latter yields only a mono, while the former yields a dichloride. At present the controversy remains undecided. (*Berichte*, xxv. 340.)

The production of pyridine derivatives from Collie's triacetic acid is mentioned in the second section of the organic part.

Lactic acid, resolution into optically active components.—The authors, T. Purdie and J. Wallace Walker, neutralise lactic acid with

strychnine and fractionally crystallise the strychnine salt. The ammonium salt obtained from least soluble crystals proves to be dextrogyrate, while that obtained from the most soluble is laevogyrate. The zinc salt obtained from the former by boiling with zinc oxide proves to be laevogyrate. It crystallises with 2 mols. of water, while ordinary zinc lactate crystallises with 3 mols. The free acid obtained from it is laevorotatory. The zinc salt of the other acid is laevorotatory (also crystallising with 2 mols. of water), the free acid being dextrorotátory. The salts are named from their acids, as zinc laevolactate and dextrolactate. When the two salts are mixed in equal proportions a precipitate of ordinary zinc lactate occurs which is found to be absolutely inactive. The dextrogyrate acid is identical with sarcolactic acid, while the laevogyrate acid is identical with the acid obtained by Schardinger by the bacterial decomposition of cane sugar. (*See* "Year-Book" for 1891, p. 184.) Schardinger has also synthesised inactive lactic acid from his laevorotatory acid and a dextrogyrate acid obtained by Lewkowitsch by the fermentation of ammonium lactate. The analytical resolution by Purdie and Walker completes the proof. (*Jour. Chem. Soc.*, lxi. 754.)

Acetacetic ether.—The constitution of acetacetic ether has of late been the subject of renewed discussion. In spite, however, of much work on the subject it cannot be said that definite conclusions have been reached. The following *résumé* will probably suggest that in its chemical relations the ether behaves now as a ketonic and now as a hydroxylic derivative—in fact, that it exhibits tautomery. **Nef** (*Annalen*, cclxvi. 52) gives a number of reasons for supposing that acetacetic ether has not the ketone structure, that it is not $CH_3.CO.CH_2.COOEt$, but $CH_3.C(OH) = CH.COOEt$, and that the monosubstituted alkyl derivatives are $CH_3.C(OH) = CR.COOEt$. Among his arguments we may notice the following:—

(1) Phenylhydrazine yields with the ether a *hydrazide* and not a *hydrazone*—that is, $CH_3.C(NH.NHC_6H_5) = CH.CO_2R$, not $CH_3.C(N.NHC_6H_5).CH_2.CO_2R$. By mercuric oxide we get phenyl *β*azocrotonic ether, $CH_3.C(N = NC_6H_5) = CH.CO_2R$.

(It is worth noting that the above hydrazide readily passes by loss of alcohol into phenylmethyl pyrazolone, which, according to this reaction, has the formula—

$$\left.\begin{array}{l} CH_3.C - NH \\ \quad\ \| \\ \ HC - CO \end{array}\right\rangle NC_6H_5 \text{ and not } \left.\begin{array}{l} CH_3.C = N \\ \qquad | \\ \ H_2C - CO \end{array}\right\rangle NC_6H_5$$

suggested by Knorr.)

(2) Acetacetic ether and its methyl and ethyl derivatives are converted by means of sodium (in alcohol) to the sodium derivatives without the reduction which would be characteristic of a ketone.

(3) **Wedel** has shown (*Annalen*, ccxix. 81 and 85) that succino-succinic ether and dioxyterephthalic acid yield with acetyl chloride diacetyl derivatives, from which it must be concluded that these bodies contain hydroxyl, especially as on standing with sodium the acetyl group is again removed.

(4) **Claisen** and **Lowman** showed (*Berichte*, xx. 651) that if we take the product of combination of sodium ethylate and ethyl benzoate, which is probably $C_6H_5.C\begin{matrix}\diagup OEt \\ -OEt \\ \diagdown ONa\end{matrix}$ and heat with acetic ether, we obtain benzoyl acetic ether, probably as follows :—

$$C_6H_5.C(OEt)_2(ONa) + CH_3.COOEt = C_6H_5.C(ONa) : CH.COOEt,$$

which gives us the hydroxylic formula for benzoyl acetic ether.

T. W. Brühl disputes Nef's conclusions. Thus with regard to (2) he cites the fact that the ether of camphor carboxyllic acid, undoubtedly ketonic, is not reduced by sodium. Nef states that a CH_2 between two carboxyls has no acid properties—*e.g.*, malonic ether is insoluble in soda and unacted on by sodium in ether. In reply Brühl remarks that this is insufficient evidence of absence of acid properties, and that free acids, such as phthalic acid, succinic acid, etc., do not react with sodium in absolute ether. Brühl also recalls his own observations on the molecular refraction of acetacetic ether, which yielded for the red hydrogen line Hα a value for $\left(\frac{n^2-1}{n^2+2}\right)\frac{P}{d}$ of 31·89. For the ketone formula theory requires 31·53, for the hydroxyl formula 32·55. (*Berichte*, xxv. 366.)

H. von Pechmann has examined formylacetic ether, which he concludes to be a hydroxyl compound $HO.CH = CH.COO\ Et$. He obtains the benzoate by the Schotten-Baumann method (acting with benzoyl chloride on the alkaline solution), and finds that this takes up bromine readily. By acting with aniline on sodium formylacetic ether he obtains anilidoacrylic ether—

$$C_6H_5.NH.CH = CH.CO_2Et.$$

This takes up a further molecule of formylacetic ether to form $C_6H_5.N\begin{matrix}\diagup CH = CH.CO_2Et \\ \diagdown CH = CH.CO_2Et\end{matrix}$ This was studied with the toluidine

derivative. These reactions obviously support the hydroxyl formula and not the aldehyde formula $H.CO.CH_2.COO\,Et$. Pechmann concludes that "formylacetic ether" is in fact the ether of *β*hydroxyacrylic acid. But Pechmann finds that its homologue acetacetic ether differs from it entirely in general behaviour—*e.g.*, it does not take up bromine. Also on benzoylating the product in the case of acetacetic ether resembles the mother substance (has acid properties, etc.), but loses them with the introduction of the *second* benzoyl group. In the case of formylacetic acid the acid properties disappear with the introduction of the *first* benzoyl group. Formylacetic acid only contains *one* replaceable hydrogen atom. Pechmann considers that these differences point to the ketone formula for acetacetic ether. (*Berichte*, xxv. 1040.)

L. Claisen considers that Nef's work does not prove his point. Acetacetic ether gives rise to two series of derivatives agreeing with either formula. Molecular refraction supports the ketone formula. He considers that Pechmann's work, which consisted in acting with benzoyl chloride on sodio-formylacetic ether, does not prove the constitution of the *free* ether. (*Berichte*, xxv. 1,776.)

Arthur Michael considers he has shown that from acetylchloride and sodiomalonic ether the true acetomalonic ether is obtained.

$$COOEt.CHNa.COOEt + CH_3COCl = COOEt.\underset{\displaystyle COCH_3}{\underset{|}{CH}}.COOEt + HCl.$$

while chlorocarbonic ether and sodacetacetic ether yield carbethoxylacetacetic ether thus—

$$\begin{array}{l|l|l} CH_3.CO & Na & :CH.COOEt \\ & Cl & CO_2Et \end{array}$$

He considers that sodacetacetic ether has the hydroxyl formula, while the free ether has the ketone formula.

W. H. Perkin has made a valuable contribution to the evidence on the constitution of acetacetic ether by his determination of its molecular magnetic rotation. With ethylacetacetate and ethylethylacetacetate the results show these compounds to be *saturated*. Thus with acetacetic ether we have :—

Rotation observed	6·501
Calculated ...	6·510
Calculated for unsaturated compound	7·849

At higher temperatures (905°) the rotation is slightly diminished, becoming 6·470.

The rotation of a number of supposed ketonic compounds is described by Perkin in the same paper (*Jour. Chem. Soc.*, lxi., 800). The diketones (*e.g.*, acetylacetone) are found to be partially hydroxylic. Thus methylacetone has a rotation lying nearly midway between the ketonic and the hydroxy-ketonic formulæ. On altering the temperature the rotation alters owing to varying proportions of the different molecules. Raising the temperature lessens the proportion of unsaturated (hydroxylic) molecules.

The sugars.

Fischer has continued his work on the sugars. Among his most interesting recent results are the syntheses of the higher sugars from glucose. The nitrile reaction was first applied to sugars by Kiliani. The lactone so obtained can, as Fischer has shown, be reduced by sodium amalgam to the sugars. He has also shown that *two* stereo-isomers are in this way obtained. In a later paper (*Annalen*, cclxx. 64) Fischer describes the syntheses from d-glucose. He combines this with hydrocyanic acid, converts the nitrile into the lactones by baryta, α and β glucoheptonic acid lactones being thus obtained, the former being less soluble. Reduced these yield α and β glucoheptose. The α-compounds are used for subsequent syntheses. In this way we get α- and β-octose and α- and β-gluconononose and its alcohol glucononite, the first nine-value alcohol.

As to the configuration of these compounds :—

$$\begin{array}{cccccccccc}
 & & H & & H & & OH & & H & \\
 & & \cdot & & \cdot & & \cdot & & \cdot & \\
CH_2OH & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot\ COH \\
 & & \cdot & & \cdot & & \cdot & & \cdot & \\
 & & OH & & OH & & H & & OH &
\end{array}$$

is glucose. For glucoheptonic acid we have thus :—

(i.)

$$\begin{array}{cccccccccccc}
 & & H & & H & & OH & & H & & H & \\
 & & & & \cdot & & & & \cdot & & \cdot & \\
CH_2OH & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot\ COOH \\
 & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & \\
 & & OH & & OH & & H & & OH & & OH &
\end{array}$$

(ii.)

$$\begin{array}{cccccccccccc}
 & & H & & H & & OH & & H & & OH & \\
 & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & \\
CH_2OH & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot\ COOH \\
 & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & \\
 & & OH & & OH & & H & & OH & & H &
\end{array}$$

corresponding to the two pentoxypimelic acids :—

(i.)

$$\begin{array}{ccccccccccccc} & & H & & H & & OH & & H & & H & & \\ & & \cdot & & & & \cdot & & & & & & \\ COOH & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & COOH \\ & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & & \\ & & OH & & OH & & H & & OH & & OH & & \end{array}$$

(ii.)

$$\begin{array}{ccccccccccccc} & & H & & H & & OH & & H & & OH & & \\ & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & & \\ COOH & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & COOH \\ & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & & \\ & & OH & & OH & & H & & OH & & H & & \end{array}$$

of which i. is *inactive* and ii. *active.*

The glucoheptonic acids are converted by oxidation into the two bibasic acids and examined optically. The pentoxypimelic acid obtained from the α-compound (first by Kiliani) is optically inactive, that from the β compound active.

We thus have for α-glucoheptose the formula :—

$$\begin{array}{ccccccccccccc} & & H & & H & & OH & & H & & H & & \\ & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & & \\ CH_2OH & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & C & \cdot & CHO \\ & & \cdot & & \cdot & & \cdot & & \cdot & & \cdot & & \\ & & OH & & OH & & H & & OH & & OH & & \end{array}$$

In the case of the gluco-octonic acids we cannot decide, since *both* their derivatives would be active.

The sugars, up to glucononose, together with their acids, hydrazones, etc., have been prepared and studied. (*Annalen*, cclxx. 64.)

Mucic acid (inactive) is investigated by **Fischer** and **Hertz** (*Berichte*, xxv. 1247). It is shown to be symmetrically built up, and on reduction yields equal quantities of stereoisomeric monobasic active acids, the symmetry of the molecule being destroyed. The lactone, which is optically inactive, consists (for the same reason) of equal quantities of oppositely rotating lactones.

The first *aromatic sugar* has been obtained by **Emil Fischer** and **A. J. Stewart.** They start with the cyanhydrin of cinnamic aldehyde.

$$C_6H_5.CH.CH.CHO + HCN = C_6H_5.CH : CH.CH\Big\langle{}^{OH}_{CN}$$

This compound readily takes up bromine and the product yields

on saponification the lactone of phenylbromhydroxybutyric acid.

$$\begin{array}{c} C_6H_5.CH.CH.CH_2.COOH \\ \vdots \quad \vdots \\ \boxed{\begin{array}{c} Br \\ K \end{array}} \; Br \\ OH \qquad\qquad \\ C_6H_5.CH.CHBr.CH_2.CO.O \end{array}$$

The above probably expresses the course of the reaction with formation of a γ-lactone. From the bromolactone the phenyltri hydroxy butyric acid is obtained by boiling with baryta-water.

$$C_6H_5.CH_2.CH_2.CH_2.COOH$$

The acid is converted even by the mere evaporation of its aqueous solution into the lactone. Reduced with sodium amalgam the lactone yields the aldehyde, $C_6H_5.CH_2.CH_2.CH_2.CHO$, which is the new sugar, phenyltetrose. The free sugar is a colourless syrup not yet obtained in the crystalline state. It reduces Fehling solution on boiling. On adding phenylhydrazine acetate to the concentrated aqueous solution of the sugar, its phenylhydrazone separates as a yellow oil, which rapidly solidifies and may be recrystallised from benzol. The hydrazone was used for analysis. (*Berichte*, xxv. 2,555.)

One of the last stones is added to the edifice of the artificial sugars by **Fischer** and **Landsteiner** in their isolation of glycol aldehyde, $CH_2OH.CHO$. The ordinary sugars being aldehyde or ketone alcohols, this substance becomes the first member of the aldehydic series (diose). Abeljanz thought he had obtained the substance by the action of water on dichlorether, while Pinner acted on his glycol acetal with acid, but as the authors show, neither of these chemists obtained glycol aldehyde. Glyceraldehyde, the original starting-point for the synthesis of the sugars, being obtained by the action of baryta-water on acrolein dibromide, there seemed some chance of preparing the glycol derivative by the action of baryta on monobromaldehyde, $CH_2Br.CHO$. The procedure is as follows :—

Bromacetal, $CH_2Br.CH\begin{cases} OC_2H_5 \\ OC_2H_5 \end{cases}$, is obtained by the action of bromine on acetal, calcium carbonate being present to destroy the liberated hydrobromic acid which interferes with the reaction.

The compound is next decomposed by heating on an oil-bath with oxalic acid.

$$CH_2Br.CH\begin{array}{l}\diagup\boxed{OC_2H_5\ \ H}\\ \qquad\qquad\ \vdots\\ \qquad\qquad\ O\\ \qquad\qquad\ \vdots\\ \diagdown\boxed{OC_2H_5\ \ H}\end{array}$$

The bromaldehyde, $CH_2Br.CHO$, is distilled off. It is a colourless, viscid liquid, of very pungent odour. The crude bromaldehyde is dissolved in water and added to baryta suspended in water, the mixture being maintained at 0°. The odour of bromaldehyde disappears. The baryta is precipitated by sulphuric acid and the solution neutralised by lead carbonate. After filtration this yields us a solution of glycolaldehyde, which reduces Fehling solution at the ordinary temperature. Warmed with phenylhydrazine acetate crystals of the osazone (glyoxalphenylosazone) are deposited and were analysed.

Bromine water oxidises glycolaldehyde to glycollic acid, $CH_2OH.COOH$, the reaction being analogous to that occurring with the sugars. Dilute sodium hydrate (1 per cent.) causes the glycolaldehyde to polymerise to *tetrose*, which was examined in the form of an osazone.

$$CH_2OH.CHO\ CH_2OH.CHO.$$
$$CH_2OH.CHOH.CHOH.CHO.$$

This is the first synthetical tetrose.

With the exception of the pentoses the synthesis of the sugars is now complete from the lowest member of the series, diose (glycolaldehyde), to nonose. (*Berichte*, xxv. 2,549.)

Another method of preparing glycolaldehyde is described by **W. Marckwald** and **Al. Ellinger**. The experiments of these authors are described in a preliminary form owing to the publication of Fischer and Landsteiner's work on the subject. The authors start from glycolacetal in the manner first attempted by Pinner. They obtain this body from chloracetal by the action of alcoholic potash—

$$CH_2Cl.CH\begin{array}{l}\diagup OC_2H_5\\ \diagdown OC_2H\end{array}\ \text{giving}\ CH_2OH.CH\begin{array}{l}\diagup OC(\\ \diagdown OC_2H_5\end{array}$$

Pinner could not succeed by means of mineral acids in splitting this compound into glycol aldehyde and ethylalcohol. The authors have, however, found that if sufficiently dilute acid be used the action proceeds easily and smoothly. Quite pure and

Compounds containing nitrogen.

Hydrazoic acid, N_3H.—It was mentioned in the last issue ("Year-Book" for 1891, p. 201) that the ideal reaction

$$NH_2.NH_2+HNO_2=HN\langle\begin{matrix}N\\ \|\\ N\end{matrix}+2H_2O$$ does not occur. True

hydrazine itself has only, as yet, been obtained from organic derivatives, and only by means of organic compounds can it be converted into hydrazoic acid, N_3H. The methods used by Curtius have already been dealt with. Phenylazoimide,

$C_6H_5.N\langle\begin{matrix}N\\ \|\\ N\end{matrix}$ (the diazobenzolimide of Griess) has been synthesised

by **E. Fischer** from phenylhydrazine and nitrous acid:—

$$C_6H_5NH.NH_2+HNO_2=C_6H_5N_3+2H_2O$$

(*Ann. Chem. Pharm.*, cxc. 92.) This substance is, it will be seen, the phenyl ether of hydrazoic acid. Could it be saponified it should yield phenol and a salt of azoimide, just as chlorobenzol, C_6H_5Cl, might theoretically be expected to yield with potash phenol and potassium chloride. But just as it is not possible to saponify chlorobenzol by potash, it is also impossible to saponify phenylazoimide. It has been found, however, that when chlorobenzol is nitrated the chlorine becomes much more susceptible of saponification. Thus chlortrinitrobenzol

$$(Cl : NO_2 : NO_2 : NO_2=1 : 2 : 4 : 6)$$

is readily saponified by boiling with soda, being converted into trinitrophenol or picric acid. **Noelting** and **Grandmougin** have applied this plan to the production of hydrazoic acid from phenylazoimide. Dinitrophenylazoimide is obtained from dinitraniline ($NH_2 : NO_2 : NO_2 = 1 : 2 : 4$) by diazotising, conversion into perbromide, and treatment with ammonia.

$$(NO_2)_2C_6H_3.NBr-NBr_2+NH_3=3HBr+(NO_2)_2C_6H_3N.\langle\begin{matrix}N\\ \|\\ N\end{matrix}$$

It is readily saponified by alcoholic potash yielding the potassium salts of dinitrophenol and of azoimide or hydrazoic acid.

$$(NO_2)_2C_6H_3.N\left<\begin{matrix}N\\ \|\\ N\end{matrix}\right. + 2KOH = (NO_2)_2C_6H_3OK + K.N\left<\begin{matrix}N\\ \|\\ N\end{matrix}\right. + H_2O$$

(*Berichte*, xxiv. 2,546.)

A still more simple and beautiful synthesis has been worked out by **Wilhelm Wislicenus**. According to this method the hydrazoic acid is obtained from purely inorganic sources. The method consists in acting upon sodamide with nitrous oxide. We have:—

$$\begin{array}{r|l} NaN & H_2 \\ N_2 & O \end{array}$$

giving us NaN_3 and water, which, of course, reacts with further sodamide, $NaNH_2 + H_2O = NaOH + NH_3$. The complete reaction is therefore:—

$$2NaNH_2 + N_2O = NaN_3 + NaOH + NH_3.$$

Potassium and zinc amides react in a similar manner with nitrous oxide.

To carry out the synthesis dry ammonia is first passed over molten sodium contained in a porcelain boat within a glass tube. When the sodium has been converted into amide the current of ammonia is replaced by one of nitrous oxide, the temperature being maintained between 150° and 250°. The mass froths up slightly and ammonia is evolved. When the evolution of ammonia ceases the reaction is at an end. The product is dissolved in water, and when treated with dilute sulphuric acid yields the free azoimide, which can be distilled off. The distillate yields the ordinary reactions of hydrazoic acid. The silver salt was precipitated and analysed. (*Berichte*, xxv. 2,084.)

II.—RING COMPOUNDS (CYCLOIDS), ETC.

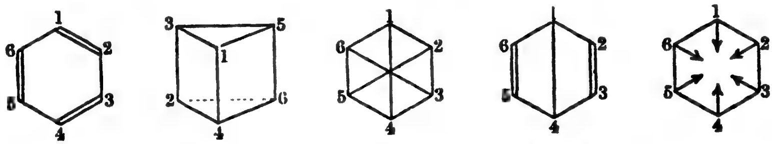
BY CHARLES FREDERIC BAKER, B.SC.

The constitution of benzene.

Another paper with this title by **Adolph von Baeyer** has appeared during the past year. In noticing this paper we propose to give a short *résumé* of Prof. von Baeyer's recent work upon the subject, as it is of more than ordinary interest and importance.

For an account of the facts, and inferences drawn from

them, which lead to our present notions of the arrangement of the atoms in the benzene molecule, a text-book must be consulted; we would refer the reader to McGowan's English translation of Bernthsen's "Organic Chemistry" (Blackie), p. 307, and, for an account of some of the formulae proposed for benzene, to Morley's "Organic Chemistry" (Churchill), p. 293, or to the article "Benzene" by the same author in the new edition of Watt's Dictionary. We will here content ourselves with recalling the chief conclusions drawn from the reactions of benzene, viz., that (1) The six carbon atoms are similar, and similarly situated in the molecule, and the hydrogen atoms are symmetrically disposed with regard to them, being themselves also similar and similarly situated; and (2) Three, and only three, series of di-substitution derivatives exist. A satisfactory benzene formula has to furnish an expression of these main facts, and of many minor ones. Various formulae have been proposed, and are reproduced below. In these formulae each figure represents a carbon atom, which is also joined to a hydrogen atom, — a CH group, in short. 1 : 2, 1 : 6, etc., substitution products would be *ortho-*, 1 : 3, 1 : 5 etc., *meta-*, and 1 : 4, etc., *para-* derivatives.



Kekule's. Ladenburg's. Claus'. Dewar's. "Central Formula."

The formula proposed by Kekulé, the originator of our present views regarding the constitution of benzene, has found the most general acceptance, and, in a somewhat simplified form, is the one commonly used. It represents the six carbon atoms as united in a chain, each being linked to two others only. It explains satisfactorily almost all the known reactions of benzene derivatives, and accounts for the existence of the substitution derivatives of various kinds, and it affords a simple explanation of the relation of benzene to naphthalene. Its weak point is the double bonds, which were inserted merely out of deference to the current opinion that the carbon atom is always tetravalent, as it certainly is in saturated, fatty compounds. These double bonds, however, possess few of the characteristics of those in ethylene compounds. And further, since a double bond is different from a single one, the compound $CH_3 - CBr = CHBr$ differing from $CH_2Br - CBr = CH_2$, the benzene derivative

[X : X = 1 : 2 see Kekulé's formula above] should differ from the [X : X = 1 : 6] derivative, and similarly C_6H_4XY [X : Y = 1 : 3] from [X : Y = 1 : 5], X and Y being unlike atoms or groups of atoms, each replacing an H of the benzene molecule, C_6H_6. Granting this, Kekulé's formula requires the compound $C_6H_4X_2$ to exist in *four*, and C_6H_4XY in *five* isomeric modifications, whereas in reality each exists only in *three*. Kekulé attempted to explain this by assuming that in consequence of vibrations within the molecule, the double bonds which at one instant occupy the positions 1 = 2, 3 = 4, 5 = 6, are at the next in 2 = 3, 4 = 5, 6 = 1, and perpetually oscillate between these positions. The difference between a 1 : 2 and a 1 : 6 disubstitution derivative thus vanishes. But this explanation is obviously a lame and unsatisfactory one—a mere evasion of the difficulty.

Ladenburg's formula, known also as the prism formula, represents the six carbon atoms as situated at the angles of a triangular prism, and linked each similarly to two others and dissimilarly to a third. This formula does not explain satisfactorily the relation of benzene to naphthalene, and gives only a very forced explanation of the existence of the addition products of benzene.

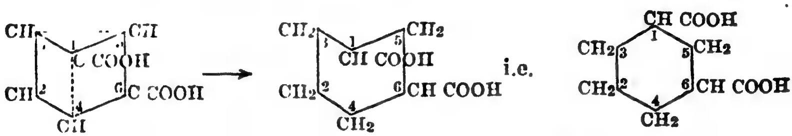
Claus' formula represents the six carbon atoms as united in a ring, and each carbon atom linked, not only to its two neighbours in the ring, but also by a "para-junction" to the opposite atom. It had not, till recently, met with general acceptance; but Baeyer, in his last paper, says that it is the only formula which affords an explanation of one of the reactions that he has observed.

The formula of Dewar (and Kœrner) has never found acceptance; it does not represent the carbon atoms as all similar.

The "central formula," proposed at various times by Lothar Meyer, Armstrong, and Baeyer, assumes that the six carbon atoms are united in a ring, each to two others and to a hydrogen atom; as to the power which, in a fatty compound, would enable each to unite with a fourth atom, this is somehow employed in producing an intramolecular tension which gives the ring its peculiar character. The conception is obviously indefinite, but this very indefiniteness makes it more nearly represent the state of our knowledge.

With regard to Baeyer's work, we may say at the outset that it has, as yet, thrown little or no light upon the constitution of benzene itself, though much upon that of its reduction droducts. Baeyer certainly disproves Ladenburg's formula, and

in this wise. When phthalic acid, an ortho-dicarboxybenzene, is reduced to hexahydrophthalic acid, a hexamethylene derivative, the carboxyl groups still remain in the ortho position in the resulting acid, for this acid, like all ortho-dicarboxylic acids, readily gives an anhydride, which the other two isomeric hexahydrophthalic acids do not. Now if Ladenburg's formula is correct, when a benzene derivative is converted into a hexamethylene one, the ortho-positions in the former become meta- in the latter, as the following figures show :—



Phthalic acid
(1 : 6 = *ortho*).

Hexahydrophthalic acid
(1 : 6 = *meta*).

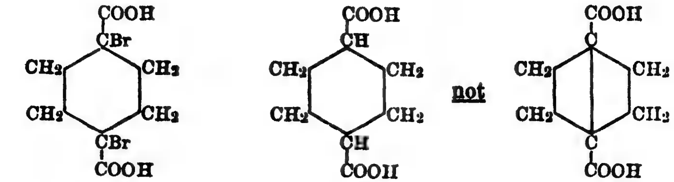
Since, then, in reality an orthobenzene derivative is found to yield an ortho, and not a meta, hexamethylene derivative, Ladenburg's formula is not in accordance with the facts.

But, beyond this, Baeyer's researches do not allow us to discriminate between the various benzene formulae. At first he revived the central formula because he considered that Kekulé's, with its three double bonds, was not in accordance with the fact that benzene derivatives, such as terephthalic acid, are not immediately attacked by permanganate. But later he found that phenanthrene is not attacked by permanganate in the cold, whereas stilbene is :—

$$C_6H_4 \Big\langle {CH = CH \atop H \qquad\; H} \Big\rangle C_6H_4 \qquad\qquad C_6H_4 \Big\langle {CH = CH \atop \overline{\qquad\qquad}} \Big\rangle C_6H_4$$

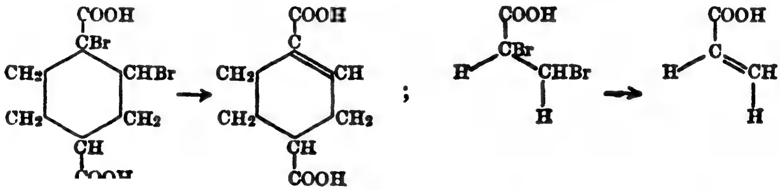
Stilbene. Phenanthrene.

and since it thus seemed that the mere fact of a double bond existing in a ring is alone sufficient to make it less readily oxidisable, there was no longer any reason why terephthalic acid should not contain three such double bonds, and their difficult oxidisability be due to their existence in a closed ring. Baeyer therefore returned to Kekulé's formula. He had formerly rejected Claus' formula, with para-junctions, because he had found that no para-junctions are formed when you would expect them. For example, when para-dibromohexahydroterephthalic acid is treated with nascent hydrogen, the two Br atoms are replaced by H, and not merely removed.



1 : 4 — Dibromo-hexahydroterephthalic acid. Hexahydro-terephthalic acid.

Now if para-junctions are capable of existence, you would expect the two Br atoms to be removed and a para-junction to be formed, just as in both hydro-benzene and fatty compounds, when the two Br atoms are attached to adjacent carbon atoms, they are removed by nascent hydrogen and a second ortho-junction is formed, converting the junction into a double bond, *e.g.*:—



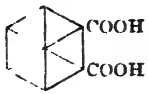
1 : 2—Dibromo-hexahydroterephthalic acid. Δ^1 Tetrahydro-terephthalic acid. α β—Dibromo-propionic acid. Acrylic acid

It seems, therefore, that there is not, as Claus' theory would require, a tendency to the formation of a para-junction.

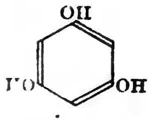
But in his last paper Baeyer shows that most of the reactions can be explained by means of Claus' formula, if it is assumed that when one para-junction is broken the other two are replaced by double bonds. And the following fact favours the idea of para-junctions. When a dihydrophthalic acid is oxidised, if one of the two H atoms removed was attached to the *same* C atom as the COOH group, or to the C atom in the *para*-position to this one, the COOH group, alike in either case loses CO_2, and benzoic acid is formed, whereas if the H atom was attached to a C atom in the *ortho*-position, no CO_2 is split off, and phthalic acid is formed. It thus seems as if there were a closer connection between two carbon atoms when in the para- than when in the ortho-position with regard to each other, and the presence of para-junctions in phthalic and benzoic acid is accordingly rendered probable.

But just as Baeyer now considers phthalic acid to contain para-junctions, so he thinks that he has, with equal certainty,

proved phloroglucinol to contain three double bonds, (*Ber.*, xxiv.



Phthalic acid.



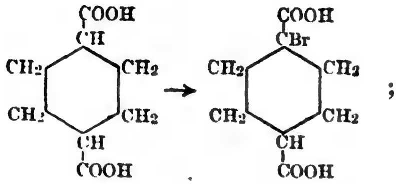
Phloroglucino.

2687), and so thinks it possible that the benzene nucleus may exist in two modifications, corresponding respectively to Claus' and to Kekulé's formulae. But no definite conclusions have yet been reached, as he ingenuously admits in the following passage:— "The task which I set before me on commencing these researches was to elucidate the constitution of benzene, and not to seek an experimental verification of any particular hypothesis. As a consequence of this resolution I have more than once changed my views, according as the sum of the experimental evidence appeared to favour one or another theory. And I would ask the reader not to be astonished because I now give prominence to an hypothesis which I have previously combated, nor to hold me inconsistent if I should chance in the course of time to transfer my allegiance to another theory."

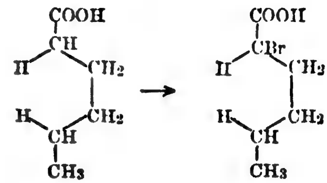
But though little knowledge has been gained of the constitution of benzene itself, much light has been shed upon that of its reduction products. Of these the di-, tetra-, and hexa-hydro addition products of terephthalic and phthalic acids have been exhaustively studied, as well as the di- and tetra-hydro homonucleal α- and β-naphthoic acids.

For these the following nomenclature is adopted. The presence of a double bond is indicated by the symbol Δ, and its position by a figure; it starts from the C atom indicated by this figure, and runs in the direction in which C atoms of the ring are numbered. For example, Δ^2 tetrahydro-terephthalic acid has a double bond between the carbon atoms 2 and 3; $\Delta^{1.3}$ dihydroterephthalic acid has two double bonds, between 1 and 2, and 3 and 4 respectively. The result of these investigations has been to show that these addition compounds possess in all respects the character of fatty derivatives; the hexamethylene compounds (hexahydro-terephthalic and phthalic acids, and the tetrahydronaphthoic acids) exhibit all the reactions of saturated fatty compounds, while the tetrahydro-terephthalic and phthalic acids and the dihydronaphthoic acids resemble unsaturated fatty compounds containing one double bond, and the dihydro-terephthalic and

phthalic acids react exactly like unsaturated fatty derivatives containing two double bonds. Hexamethylene derivatives yield no addition products with bromine, but substitution derivatives, in which, as in the fatty series, the Br goes to the α carbon atom reckoned from the COOH group.

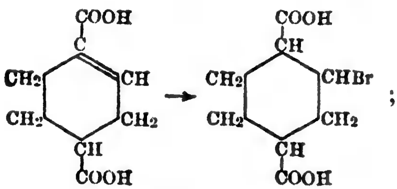


Hexahydro-terephthalic acid. 1—Bromohexahydro-terephthalic acid.

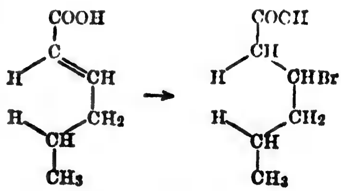


Caproic acid. α—Bromo-caproic acid.

And tetrahydro-phthalic acid, etc., takes up 2H, 2Br, or HBr, yielding hexamethylene derivatives, just as ethylene derivatives under similar circumstances yield saturated fatty compounds. And dihydroterepthalic acid, etc., unites with 2H, 2Br, or HBr, giving tetrahydro derivatives, and with 4H, 4Br, or 2HBr, giving hexamethylene derivatives, just as fatty compounds with two double bonds yield successively ethylene derivatives and saturated fatty compounds. And when a tetrahydro acid takes up HBr, the Br atom, as in the case of an unsaturated fatty acid, goes to the C atom more remote from the COOH group.

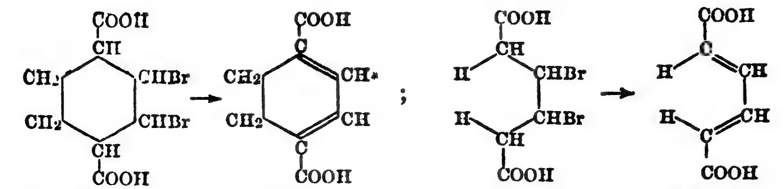


Δ^1 Tetrahydro-terephthalic acid. 2—Bromohexahydro-terephthalic acid.



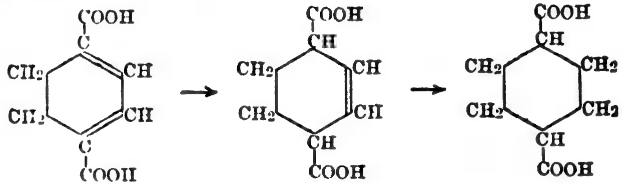
β—Propyl-acrylic acid. β—Bromo-caproic acid.

And when these bromo acids are reduced with nascent hydrogen, the Br is replaced by H, as in the fatty series. Or if they contain two Br atoms, united to adjacent C atoms, these two Br atoms are removed by nascent hydrogen, with formation of a double bond, again as in the fatty series. (See the case of 1 : 2—dibromohexahydrophthalic acid on p. 224.) And yet again, as in the fatty series, HBr is removed from these acids by the action of alcoholic potash, and double bonds are formed.

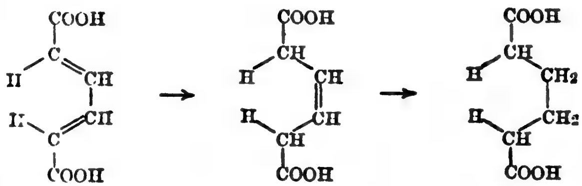


2 : 3—Dibromo-hexahydro-terephthalic acid. $\Delta^{1,3}$ Dihydro-terephthalic acid. $\beta\gamma$—Dibrom-adipic acid. Muconic acid.

And yet a further analogy exists between the gradual reduction by nascent hydrogen of $\Delta^{1,3}$ tetrahydroterephthalic acid and of the fatty muconic acid :—

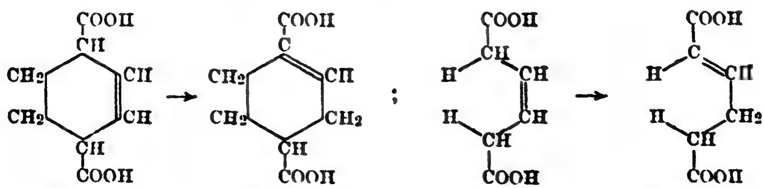


$\Delta^{1,3}$ Dihydro-terephthalic acid. Δ^{2} Tetrahydro-terephthalic acid. Hexahydro-terephthalic acid



Muconic acid. $\beta\gamma$—Hydromuconic acid. Adipic acid.

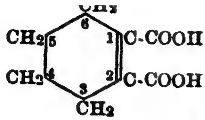
And yet again, Δ^2 tetrahydroterephthalic acid and the fatty $\beta\gamma$-hydromuconic acid undergo a precisely similar molecular transformation when boiled with caustic soda—



Δ^{2} Tetrahydro-terephthalic acid. Δ^{1} Tetrahydro-terephthalic acid. $\beta\gamma$—Hydro-muconic acid. $\alpha\beta$—Hydro-muconic acid.

Also when these di- and tetra-hydro compounds are oxidised with permanganate, the ring is broken at the double bonds, just as in the case of unsaturated fatty substances.

And how closely the properties of these compounds resemble those of the corresponding fatty substances is evident from the following tabular comparison of a few selected substances :—



Δ′ tetrahydrophthalic acid.

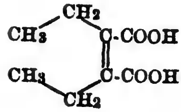
Transformed into the anhydride when heated moist on the water-bath.

The anhydride volatilises readily when heated on the water-bath.

The anhydride does not combine with bromine at the ordinary temperature.

The methyl ester readily combines with bromine.

Not reduced in the cold by sodium amalgam, but if boiled for four hours yields hexahydrophthalic acid.



σ-diethylmaleic acid.

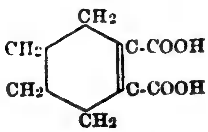
Exists in the free state only as the anhydride.

The anhydride volatilises readily when heated on the water-bath.

The anhydride does not combine with bromine at the ordinary temperature.

The methyl ester readily combines with bromine.

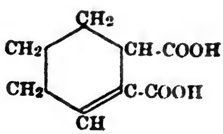
Not reduced in the cold by sodium amalgam, but if boiled for several hours yields diethylsuccinic acid.



Δ[1] tetrahydrophthalic acid.

Melts at 120°, becoming converted into the anhydride, which melts at 74°.

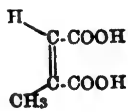
Converted when heated with aqueous potash into



Δ[2] tetrahydrophthalic acid.

This acid, when treated with acetyl chloride, gives an anhydride melting at 79°.

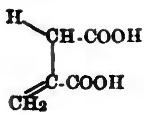
The acid melts at about 215°, losing water and forming the anhydride, which at this temperature is converted into the anhydride of the Δ[1] acid.



Citraconic acid.

Melts at 80°, becoming converted into the anhydride, which melts at 7°.

Converted when heated with water at 150° into



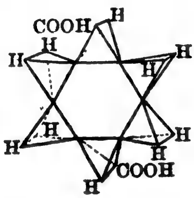
Itaconic acid.

This acid, when treated with acetyl chloride, gives an anhydride melting at 68°.

The acid melts at about 161°; when distilled under atmospheric pressure, it, as well as its anhydride, is converted into the anhydride of citraconic acid.

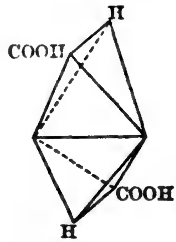
And geometrical isomerism, too, of the kind which exists in the fatty series between fumaric and maleic acid (*see* "Year-Book" for 1891, p. 211), also exists among the reduction products of benzene, as, for example, between the two hexahydroterephthalic acids; the properties of these are compared below with those of fumaric and maleic acids.

In the solid formulae given for hexahydroterephthalic acid the carbon atoms of the ring are represented by tetrahedra, at the angles of which are the groups to which they are united. In one form both COOH groups are on one side (*cis*) of the plane in which the carbon atoms lie, in the other form one is on one side and the other on the other side (*trans*).



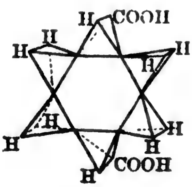
Fumaroid, Γ-cistrans or trans hexahydroterephthalic acid.

Crystallises in short prisms.
When heated sublimes, and melts at 300°.



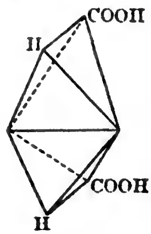
Fumaric acid.

Crystallises in small prisms.
Sublimes at 200° when heated in a current of air.



Maleinoid Γ-cis, or cis hexahydroterephthalic acid.

Crystallises in large plates.
Melts at 161°–162°.
Much more soluble in water than the fumaroid form.
Transformed into the fumaroid form when heated with hydrochloric acid.



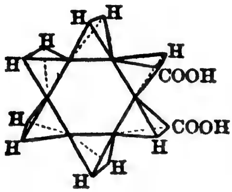
Maleic acid.

Crystallises in large plates.
Melts at 130°.
Much more soluble in water than fumaric acid.
Transformed into fumaric acid when heated with hydrochloric acid.

Hexahydrophthalic acid also exists in two forms, thus

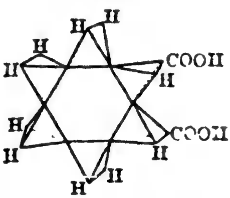
exhibiting a geometrical isomerism which finds its analogue in the fatty series rather in the isomerism of the fumaroid (optically active) and maleinoid (inactive) configurations of σ-dimethyl-succinic acid, than in that of fumaric and maleic acids.

Hexahydrophthalic acid.



Fumaroid form.

Melts at 215°, and when treated with acetyl chloride forms an anhydride, which melts at 140° and when heated is transformed into the anhydride of the maleinoid form.

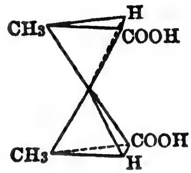


Maleinoid form.

Melts at 192°; its anhydride at 32°.

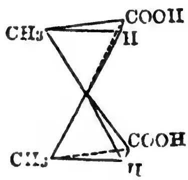
More soluble in water than the fumaroid form. Transformed into this latter when heated with hydrochloric acid.

σ-Dimethylsuccinic acid.



Fumaroid form.

Melts at 192°, and when treated with acetyl chloride forms an anhydride which melts at 38° and when heated is transformed into the anhydride of the maleinoid form.



Maleinoid form.

Melts at 120°–123°; its anhydride at 87°.

More soluble in water than the fumaroid form. Transformed into the latter when heated with hydrochloric acid.

It will thus be seen that a very close analogy exists between the reduction products of terephthalic and phthalic acids and fatty compounds. Just as in the fatty series we pass from a saturated to an ethylene, and from an ethylene to a diethylene derivative, so we pass from a hexahydro- to a tetrahydro-, and from a tetrahydro- to a dihydro-phthalic acid. But the change from a dihydro-phthalic acid to phthalic acid is of a different kind, and the resulting phthalic acid has not the character of a tri-ethylene derivative. It is possible, on the assumption that

this change does resemble that from a hexa- to a tetra-, and from a tetra- to a dihydro-acid, to calculate approximately the properties of phthalic acid (1) if the two C atoms to which the two COOH groups are united are joined by a double bond, and (2) if they are joined by a single bond. The properties of the real acid, however, do not agree with those of either of these hypothetical ones, but are intermediate in character. The change from a dihydrophthalic acid to phthalic acid does not, therefore, consist in the introduction of a third double bond. As before stated, Baeyer inclines to the view that phthalic acid contains para-junctions.

Here the matter at present rests. The constitution of benzene itself is still undetermined; its reduction products, however, have been shown to exhibit a complete analogy with fatty compounds, saturated and unsaturated.

(Baeyer, "The Constitution of Benzene," *Annalen*, ccxlv. 103, ccli. 257, cclvi. 1, cclviii. 1, 145, cclxvi. 169, cclxix. 145.)

Benzene derivatives.

Substitution in benzene derivatives.—**Crum Brown** and **Gibson** (*J. Chem. Soc.*, 1892, 367) give the following rule. If the radical already present in the benzene molecule forms with hydrogen a compound that can be converted by direct oxidation (*i.e.*, oxidation in one step) into the corresponding hydroxyl compound, then, by a further substitution in the benzene molecule, a meta (*m*) derivative is formed; in the opposite case, ortho and para (*o—p*) derivatives. In the following table A is the mono-substituted benzene derivative, B the substituting group in it, C is the compound of B with hydrogen, and is furnished with an asterisk in those cases in which it cannot be converted *by direct oxidation* into the corresponding hydroxyl derivative D. In these cases A yields, as column E indicates, *ortho* and *para* derivatives on further substitution; in the other case *meta* derivatives.

A	B	C	D	E
C_6H_5Cl	.Cl	HCl*	HOCl	*o—p*
C_6H_5Br	.Br	HBr*	.HOBr	*o—p*
$C_6H_5CH_3$	$.CH_3$	HCH_3*	$HOCH_3$	*o—p*
$C_6H_5NH_2$	$.NH_2$	HNH_2*	$HONH_2$	*o—p*
C_6H_5OH	.OH	HOH*	HO.OH	*o—p*
$C_6H_5NO_2$	$.NO_2$	HNO_2	$HO.NO_2$	*m*
$C_6H_5CCl_3$	$.CCl_3$	$HCCl_3$*	$HO.CCl_3$	*o—p*
$C_6H_5CO.H$	.CO.H	HCO.H	HO.CO.H	*m*
$C_6H_5CO.OH$	.CO.OH	HCO.OH	HO.CO.OH	*m*
$C_6H_5SO_2.OH$	$.SO_2.OH$	$HSO_2.OH$	$HO.SO_2.OH$	*m*
$C_6H_5CO.CH_3$	$.CO.CH_3$	$HCO.CH_3$	$H.CO.CH_3$	*m*
$C_6H_5CH_2CO.OH$	$.CH_2.CO.OH$	$H.CH_2.CO.OH$*	$HO.CH_2.COOH$	*o—p*

Schöpf (*Ber.*, xxiv. 3771) has shown that if a halogen atom exists in a benzene ring in which there are two negative groups, like or unlike in the ortho and para position relatively to this atom, then other groups, such as .NH, .NHR, and .OH, can easily be substituted for the halogen, but if only *one* negative group is present, no such replacement occurs, except when this one group is $.NO_2$. The negative groups may be $.NO_2$, $.SO_3H$, .COOH, .CO.R, or .CO.H.

Claus (*J. Pr. Chem.* [2], xliii. 355, *cp.* Schöpf, *Ber.*, xxiv. 3766, 4252) finds that when haloid-derivatives of benzene are treated with an acid chloride, R.COCl, the group .CO.R goes in the para position relatively to the halogen atom.

Haeusserman and **Beck** (*Ber.*, xxv. 2445) show that when orthonitrotoluene is chlorinated at 120-130° in presence of sulphur, orthonitrobenzyl chloride is formed, the halogen substituting in the side chain.

Isomeric change.—When bromine is added to a boiling solution of *meta*dichloroquinone, dibromo *para*dichloroquinone is obtained; possibly a tetrabromo addition product is formed as an intermediate stage. (**Ling**, *J. Chem. Soc.*, 1892, 570.)

Influence of CH_3 *group in the ortho position on the character of Aromatic Amines.*—According to **Rosenstiehl** (*Comptes Rendus*, cxv. 180), a CH_3 group in the ortho position to the N atom gives a secondary amine certain characters of a tertiary one, a tertiary amine with free para position the character of a para-substituted amine, and a para-substituted amine that of an unsymmetrical diamine.

3:4 — $C_6H_4(CH_3).NHCH_3$	behaves like		$C_6H_5.N(CH_3)_2$
3:4 — $C_6H_4(CH_3).N(CH_3)_2$	,,	,,	1:4 — $CH_3.C_6H_4.$
			— $NH_2.C_6H_4.N(CH_3)_2$
1:3:4—$NH_2.C_6H_3(CH_3).N(CH_3)_2$	,,	,,	1:4—$NH(CH_3).C_6H_4.N(CH_3)_2$

Action of arsenious chloride on tertiary aromatic amines.—**Michaelis** and **Schenk** (*Ber.*, xxi. 1497, *Annalen*, cclx. 1) found that when phosphorous chloride, PCl_3, acts upon dimethylaniline in presence of aluminium chloride, a H of the benzene ring is replaced by PCl_2, $(CH_3)_2N.C_6H_4.PCl_2$ being formed. Michaelis and Rabinerson (*Annalen*, cclxx. 139) now find that arsenious chloride, $AsCl_3$, reacts even more readily, no aluminium chloride being required, and forms the compounds dimethylaniline chlorarsine, $(CH_3)_2\,N.C_6H_4.AsCl_2$, and tertiary arsenodimethylaniline, $[(CH_3)_2\,N.C_6H_4.]_3As$. Both of these have basic properties, but the former also dissolves in alkalies, forming salts corresponding to the oxide $(CH_3)_2N.C_6H_4.AsO$. This oxide yields the corresponding chloride, bromide, iodide, and sulphide, and,

when reduced with sodium amalgam, arsenodimethylaniline $[(CH_3)_2N.C_6H_4.As]_2$. The analogous ethyl derivatives were also prepared.

Addition products of nitriles.—It has been shown by **Biltz** (*Ber.*, xxv. 2533), especially in the case of aromatic nitriles, that the addition products with 2 mols. HI are amido-iodides, *e.g.*—

$$\underset{\text{Benzonitrile}}{C_6H_5.CN} + 2HI = \underset{\text{Benzamido-iodide}}{C_6H_5.CI_2.NH_2}$$

The amido-iodides are solid substances, melting above 100° with decomposition, and decomposed into nitrile and hydriodic acid by distillation, or by treatment with water.

Diazo compounds.—To determine whether the products of the action of diazobenzene chloride on phenols are to be regarded as

hydroxyazo compounds or quinonehydrazones
e.g., $HO.C_6H_4.N : N.C_6H_5$ — *e.g.*, $O : C_6H_4 : N.NH.C_6H_5$

Jacobsen and **Fischer** (*Ber.*, xxv. 992; *cp.* Goldschmidt and others, *Ber.*, xxiii. 487, and xxiv. 2300) have investigated the reduction of the ethyl ether of parahydroxyazobenzene. They find it to have the hydroxyazo constitution $C_2H_5O.C_6H_4.N : N.C_6H_5$, for it yields, when reduced, paraphenetidine, $C_2H_5O.C_6H_4.NH_2$, and aniline $NH_2.C_6H_5$. Other products were also obtained, but these we cannot discuss here.

Synthesis of diphenyl derivatives from diazocompounds.—**Hensler** (*Annalen*, cclx. 227) observed that when diazoamido benzene, $C_6H_5.N : N.NH.C_6H_5$ is heated, diphenyl, and para- and ortho-amido diphenyl, $C_6H_5.C_6H_4.NH_2$, are formed together with other products. **Hirsch** (*Ber.*, xxiii. 3705) found that, when diazobenzene is heated with phenol, ortho- and para-hydroxy diphenyl are formed, and when it is heated with aniline, ortho- and para-amido diphenyl. (*Ber.*, xxv. 1873.)

Action of diazobenzene on malonic acid.—It appears that in a hydrazone in which the group $C_6H_5.NH.N{=}C{<}$ is combined with .H, .COOH, or .CO.R, each of these latter groups is replaceable by the action of diazobenzene in alkaline or acetic acid solution. Take the case of malonic acid.

$$\underset{\text{malonic acid}}{H_2C\left\langle\begin{matrix}COOH\\COOH\end{matrix}\right.} \qquad \underset{\text{benzenehydrazomalonic acid}}{C_6H_5.NH.N : C\left\langle\begin{matrix}COOH\\COOH\end{matrix}\right.}$$

$$\underset{\text{formazyl carboxylic acid}}{C_6H_5.NH.N \quad C\left\langle\begin{matrix}N : N.C_6H_5\\COOH\end{matrix}\right.} \qquad \underset{\text{formazyl azobenzene}}{C_6H_5.NH.N : C\left\langle\begin{matrix}N : N.C_6H_5\\N : N.C_6H_5\end{matrix}\right.}$$

By the action of diazobenzene upon its ester benzenehydrazomalonic acid is formed. If the acid itself be used, formazyl carboxylic acid is obtained, together with formazyl,

$$C_6H_5{\cdot}NH{\cdot}N:C\left\langle\begin{matrix}N:N.C_6H_5\\CH\end{matrix}\right.$$

which can also be got by heating its carboxylic acid. The latter can also be obtained by the action of diazobenzene upon the ethyl-hydrogen salt of benzenehydrazomalonic acid, carbon dioxide being driven off. By the further action of diazobenzene upon formazyl or its carboxylic acid, formazyl-azobenzene is obtained. Analogous reactions were observed in the case of similar compounds. These azohydrazones are mostly dark-red, well-crystallised substances, readily soluble in benzene chloroform, and acetone, less so in other solvents. They possess but feeble basic and acid properties. With concentrated sulphuric acid they give blue solutions which, on dilution, become red, and then colourless. On reduction they yield colourless hydrazones. (**Pechmann**, *Ber.*, xxv. 3175.) Formazyl carboxylic acid can also be obtained by the action, under certain circumstances, of diazobenzene on ethyl acetacetate—$H_2C\left\langle\begin{matrix}CO.CH_3\\COOC_2H_5\end{matrix}\right.$; under other circumstances ethyl benzene azoacetacetate $C_6H_5.NH.N:C\left\langle\begin{matrix}CO.CH_3\\COOC_2H_5\end{matrix}\right.$ is formed. (**Bamberger** *Ber.*, xxv. 3201, 3539, 3547.) It has also been obtained (**Wislicenus** and **Jensen**, *Ber.*, xxv. 3448, 3456) by the action of diazobenzene on ethyl oxalylacetate $H_2C\left\langle\begin{matrix}CO.COOC_2H_5\\COOC_2H_5\end{matrix}\right.$. By the action of diazobenzene on the hydrazones of benzaldehyde and glyoxylic acid formazylphenyl and formazylazobenzene were respectively prepared.

Condensation of phenols with unsaturated hydrocarbons, with ketones—Phenol, in the presence of strong sulphuric acid and acetic acid, forms condensation products with isoamylene, cinnamene, dihydronaphthalene, and terpene in the following manner:—

$$\underset{\text{phenol}}{HO.C_6H_7.H}+\underset{\text{isoamylene}}{C_5H_{10}}=\underset{\text{para-isoamylphenol}}{HO.C_6H_4.C_5H_{11}}$$

Pyrocatechol, resinorcinol, and quinol yield di-isoamyl derivatives; pyrogallol also yields a di- and not a tri-isoamyl derivative. (**Koenigs**, *Ber.*, xxiii. 3144, xxiv. 179, 3889, xxv. 2649.)

Phenol, in the presence of fuming hydrochloric acid, condenses thus with fatty aromatic ketones :—

$$\begin{matrix}R\\R\end{matrix}\!>CO+\begin{matrix}H.C_6H_4.OH\\H.C_6H_4.OH\end{matrix}=H_2O+\begin{matrix}R\\R\end{matrix}\!>C<\begin{matrix}C_6H_4.OH(p)\\C_6H_4.OH(p)\end{matrix}$$

and the resulting products, when fused with an alkali, or treated with strong hydrochloric acid, yield a para-substituted phenol $CHR_2.C_6H_4.OH(p)$, and quinol $HO.C_6H_4.OH(p.)$. (**Dianin**, *J. Russ. phys. chem. Soc.*, 1891 [1], 488, 523, 601.)

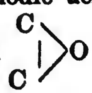
β-naphthol condenses with formaldehyde, forming β-dinaphtholmethane (**Abel**, *Ber.*, xxv. 3477),

$$CH_2O+2H{\cdot}C_{10}H_6{\cdot}OH=H_2O+CH_2({\cdot}C_{10}H_6{\cdot}OH)_2$$

Synthesis of the sixth dihydroxytoluene, $CH_3.C_6H_3.(OH)_2$ $[CH_3:(OH)_2=1:2:3]$. This was accomplished by converting amido-methoxycresol $[CH_3:OCH_3:NH_2=1:2:3]$ by the diazo reaction into the methoxycresol $[CH_3:OCH_3:OH=1:2:3]$ and heating this with hydrochloric acid. It differs from isorcinol to which Beilstein assigns the 1 : 2 : 3 formula; this latter is, probably identical with one of the other isomers. A table of the six dihydroxytoluenes is given below.

Name.	Cresorcinol.	Symmetrical (meta) orcinol.	Ortho-ortho-dihydroxy-toluene	Hydrotolu-quinone	Homo-pyro-catechol.	Isohomo-pyro-catechol.
$CH_3:(OH)_2=$	1:2:4	1:3:5	1:2:6	1:2:5	1:3:4	1:2:3
m.p.	103–104°	107°	63–66°	124°	Syrup	47°
b.p.	267–270°	287–290°	—	—	—	238–240°
Colour with $FeCl_3$	Greenish-blue	Violet-black	—	Brownish-red	Green	Green

(**Limpach**, *Ber.*, xxiv. 4136.)

Limettin, $C_6H_3\left\{\begin{matrix}(OCH_3)_2\\C_3HO_2\end{matrix}\right.$.—A substance melting at 147·5° obtained from the fruit of the lime. 2 H-atoms can be replaced by Br, 3 by Cl, or 2 by Br and 1 by Cl simultaneously, and 1 by NO_2. Permanganate oxidises it to oxalic acid and some acetic, chromic acid to carbon dioxide and acetic acid. With hydriodic acid 2 mols CH_3I are formed. It probably contains a 
group, for moderately strong sulphuric acid converts it into a

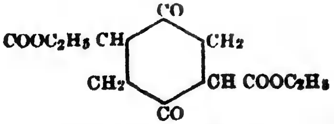
substance which gives a diacetyl derivative, and hence contains the group $\begin{array}{l} C—OH \\ | \\ C—OH \end{array}$. (Tilden, *J. Chem. Soc.*, 1892, 344.)

Myristicin, obtained from nutmeg oil and mace oil, has been found to be oxymethylenemethoxybutenylbenzene, $CH_2\langle\begin{smallmatrix}O\\O\end{smallmatrix}\rangle C_6H_2(OCH_3).C_4H_7$. When oxidised with permanganate it yields myristic acid $CH_2\langle\begin{smallmatrix}O\\O\end{smallmatrix}\rangle C_6H_2(OCH_3).COOH$, in which the oxymethelene and methyoxyl groups occupy the positions 3 : 4 : 5, the carboxyl (and consequently the butenyl in myristicin) being in 1, for the acid when heated with hydriodic acid yields gallic acid [$COOH : (OH)_3 = 1 : 3 : 4 : 5$]. (Semmler, *Ber.*, xxiii. 1803, xxiv. 3818.)

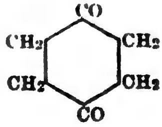
Melting-point of Pyrogallol.—Pyrogallol may be obtained pure by heating gallic acid with aniline or other aromatic bases; it melts at 132°, not at 115° as usually given. (Cazeneuve, *Comptes Rendus*, cxiv. 1485.)

An aromatic sugar.—The first sugar containing an aromatic radical has been prepared; it is phenyltetrose, $C_6H_5.CHOH.CHOH.CHOH.CHO$. See p. 216. (E. Fischer, *Ber.*, xxv. 2555.)

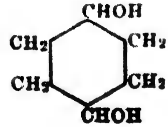
Quinitol, the simplest sugar of the Inositol group.—By hydrolising ethyl succinosuccinate paradiketohexamethylene is obtained, and this, when reduced, yields a paraglycol, quinitol, apparently in two geometrically isomeric forms. Quinitol melts, trans- at 142–149°, cis- at 89-90, sublimes unchanged, dissolves readily in alcohol and water, and tastes at first sweet, afterwards bitter. It yields a diacetyl derivative, and when oxidised gives quinone.



ethyl succino succinate



paradiketohexamethylene



quinitol

Hydrobenzoic acids.—Those enumerated below have been prepared by methods similar to those employed by Baeyer in the case of the hydro-phthalic and terephthalic acids (see p. 225); with these latter acids they exhibit great similarity. (Aschan, *Ber.*, xxiv. 1867, 2617, xxv. 886, and Markownikoff, *Ber.*, xxv. 370, 3355.)

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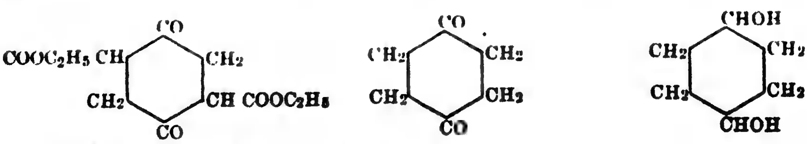


ethyl succino succinate — paradiketohexamethylene — quinitol

Hydrobenzoic acids.—Those enumerated below have been prepared by methods similar to those employed by Baeyer in the case of the hydro-phthalic and terephthalic acids (see p. 225); with these latter acids they exhibit great similarity. (**Aschan**, *Ber.*, xxiv. 1867, 2617, xxv. 886, and **Markownikoff**, *Ber.*, xxv. 370, 3355.)

	Hydrobenzoic Acids.			
	Dihydro- $\Delta^{1,3}$	Tetrahydro- Δ^1	Tetrahydro- Δ^2	Hexahydro-
m.p.	73°	Oil.	Oil.	28°
b.p.	—	235–236°		232–233°

Hydrophthalic acids.—(**Baeyer**, *Annalen*, cclviii. 145, cclxix. 145; see also p. 228.) All the theoretically possible acids, with the exception of cis- and trans- Δ^3 tetrahydro, and $\Delta^{2,5}$ and $\Delta^{1,3}$ dihydro-phthalic acids, have been prepared. It will be remembered that *all* the possible hydrop*tere*phthalic acids were obtained.

m.p.	Didyhydro- $\Delta^{1,4}$	$\Delta^{2,4}$	$\Delta^{2,6}$	Trans $\Delta^{3,5}$	cis.
Acid	153°	179–180°	215°	210°	173–175°
Anhydride	134–135°	103°	81–82°	—	99–100°

m.p.	Tetrahydro- Δ^1	Δ^2	Δ^4 Trans.	Δ^4 cis.	Hexahydro- Trans.	Cis.
Acid	120°	215°	218°	174°	221°	192°
Anhydride	74°	78–79°	140°	58–59°	140°	32°

Synthesis of Hexahydroterephthalic Acid.—(**Mackenzie** and **W. H. Perkin**, Jun., *J. Chem. Soc.*, 1892, 172.) The following are the stages:—

$$\underset{\text{ethyl sodiomalonate}}{2(COOC_2H_5)_2CHNa} + \underset{\text{ethylene bromide}}{Br.CH_2.CH_2.Br}$$

$$= NaBr + \underset{\text{ethyl butanetetracarboxylate}}{(COOC_2H_5)_2CH.CH_2.CH_2.CH(COOC_2H_5)_2}$$

(2.)

$$(COOC_2H_5)_2C\left\langle\begin{matrix}CH_2.CH_2\\ Na \quad\quad Na\end{matrix}\right\rangle C(COOC_2H_5)_2 + Br - CH_2.CH_2 - Br$$

ethyl sodio-butanetetracarboxylate ethylene bromide

$$= 2NaBr + (COOC_2H_5)_2C\left\langle\begin{matrix}CH_2.CH_2\\ CH_2.CH_2\end{matrix}\right\rangle C(COOC_2H_5)_2$$

ethyl hexamethylenetetracarboxylate

(3.)

$$(COOH)_2C\left\langle\begin{matrix}CH_2.CH_2\\ CH_2.CH_2\end{matrix}\right\rangle C(COOH)_2 \text{ when heated at } 200\text{–}220^\circ$$

hexamethylenetetracarboxylic acid

$$= 2CO_2 + COOH.CH\left\langle\begin{matrix}CH_2.CH_2\\ CH_2.CH_2\end{matrix}\right\rangle CH.COOH$$

hexahydroterephthalic acid (*m. p.* 159–162°)

In a similar manner, starting from ethyl pentanetetracarboxylate and methylene bromide, or propanetetracarboxylate and trimethylene bromide, hexahydroisophthalic (hexamethylene metadicarboxylic) acid can be obtained. In this case both the cis and trans varieties are obtained; in the case of hexahydroterephthalic acid certainly the trans, and probably the cis also.

Syntheses of benzene derivatives, especially of 1 : 3 : 5—triphenylbenzene, have been accomplished, starting with derivatives of acetophenone. (*Delacre*, *Acad. roy. de Belgique* [3], xxii. 470; abstract in *J. Chem. Soc.* Abstr., 1892, 993.)

Naphthenes.—A general paper by **Markownikoff** has appeared on these hydrocarbons (*J. pr. Chem.* [2], xlv. 561; xlvi. 86, and *J. Russ. Chem. Soc.*, xxii. 275.). The naphthenes C_nH_{2n} are to be regarded as identical with hexa-hydrobenzene and its homologues. They are saturated compounds; their monobromo derivatives lose HBr, etc., and form naphthylenes C_nH_{2n-2}, a class of unsaturated hydrocarbons to which belong the tetrahydrobenzenes, and several hydrocarbons obtained by distilling camphor, etc.

Aschan (*Ber.*, xxiv. 2618) did not find naphthene carboxylic acid to be identical with hexahydrobenzoic acid. (Cp. Markownikoff, *Ber.*, xxv. 3355.)

Synthesis of dihydrobenzene (**Baeyer**, *Ber.*, xxv. 1840).—When quinitol (see p. 236) is treated with HBr, OH is replaced by Br, and two geometrically isomeric paradibromohexamethylenes are formed. If these are heated with quinoline, 2HBr is lost and dihydrobenzene, either $\Delta^{1,3}$, or $\Delta^{1,4}$ is formed. This hydrocarbon, from its properties, appears to be the simplest member of the group of terpenes to which limonene belongs. It unites with

2HBr, 4Br; the tetrabromide is reconverted into the hydrocarbon by zinc dust and acetic acid. It reduces permanganate.

Synthesis of dihydroparaxylene (**Baeyer**, *Ber.*, xxv. 2122).—If the sodium derivative of ethyl succinosuccinate (see p. 236) is treated with methyl iodide, ethyl dimethylsuccinosuccinate is formed. This can be converted into dihydroparaxylene, probably $\Delta^{1,4}$, in the same way as ethyl succinosuccinate into dihydrobenzene (see above). Dihydroparaxylene is an unstable substance boiling at 133—134°, and having the odour of turpentine; it reduces permanganate and forms both addition and substitution products with bromine. It is probably a terpene of the limonene series.

Terpenes.

A vast amount of literature on this subject has appeared during the past year, chiefly in the *Berichte* and *Annalen*, and to a less extent in the *Comptes Rendus*. It is largely of a polemical character, and the controversy between Wallach and Brühl culminates (*Ber.*, xxv. 2087) in a criticism by the latter of Wallach's arguments and polemical methods—an aggressive criticism of a somewhat personal nature, and altogether of a kind to which chemists, in these peaceful latter days, have grown unaccustomed. As nothing conclusive has been arrived at regarding the constitution of any terpene derivative, we shall confine ourselves to noticing a few of the more interesting facts discovered, merely remarking, as regards theory, that **Brühl** has suggested (*Ber.*, xxiv. 3373) a tetramethylene formula for camphoric acid, and a di-tetramethylene one for camphor; **Collie** (*Ber.*, xxv. 1108) has proposed a tri-tetramethylene formula for camphene, and a combination of a hydrogenised benzene ring with a tetramethylene ring in the case of borneol, camphor, etc.; **Oddo** (*Gazzetta*, xxi. [2], 505) represents camphor as containing two hydrogenised benzene rings united in the meta position; **Friedel** (*Comptes Rendus*, cxiii. 825; *cp.* **Brühl**, *Ber.*, xxv. 1788) accepting Kekulé's formula for camphor, regards camphoric acid (isocamphoric acid) as a keto-hydroxy-hexahydrocuminic acid; **Cazeneuve** (*Comptes Rendus*, cxv. 825), having obtained a substance—

$$C_6H_3\,(NH_2)\,(OH)\,(C_3H_7)\,[1:3:4]$$

indirectly from camphor, thinks that the latter must contain a paracymene nucleus; and **Stohmann** and **Kleber** (*J. pr. Chem.* [2], xlv. 475) show that the heat of combustion of camphoric acid agrees best with that required by Armstrong's formula, which represents the acid as a hexamethylene derivative.

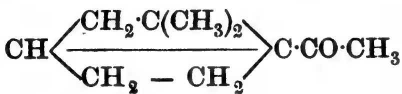
Fenchone (**Wallach**, *Annalen*, cclxix. 326; cclxxii. 108; *cp.* "Year-Book" for 1891, 237). New derivatives of + fenchone have been prepared, and the missing—fenchone has been discovered in Thuja-oil. The derivatives of this latter substance melt and boil at the same temperatures, and have the same specific gravities and refractive indices as the corresponding derivatives of + fenchone; they have also a specific rotatory power equal in magnitude but opposite in direction. And the two series of derivatives are related to each other as the two active tartaric acids to racemic acid; if equal quantities of a + and − derivative are mixed, the product is inactive, and melts at a different temperature from the original substances. Some of these fenchone derivatives are tabulated below:—

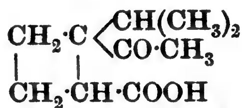
		Melting point.	
	[illegible]	Active.	Inactive.
Fenchone, $C_{10}H_{16}O$	$\pm 66{\cdot}9$–$71{\cdot}8°$	5°	—
Alcohol, $C_{10}H_{17}OH$	$\mp 10{\cdot}3°$	40°	33–35°
Oxime, $C_{10}H_{16}NOH$	± 48–$66°$	160–161°	158–160°
α-Isoxime	$\pm$	114–115°	98–99°
β-Isoxime	$\pm$	137°	160–161°
Fenchylamine $C_{10}H_{17}NH_2$ ...	$\mp 24{\cdot}6°$	Liquid.	—
Benzylidene - fenchylamine $C_6H_5CH{=}N.C_{10}H_{17}$ ...	$\pm 62{\cdot}1°$	42°	Liquid.
Orthohydroxy- " $C_6H_4(OH)CH{=}N.C_{10}H_{17}$ ...	$\pm$	95°	64–65°
Phenylfenchylsulphurea $NH(C_6H_5).CS.NH.C_{10}H_{17}$ ..		152–153°	169–170°

Thuja-oil also contains *thujone*, $C_{10}H_{18}O$, a liquid boiling at 210—212°, and apparently an unsaturated compound. When treated with ammonium formate this yields *thujonamine*, $C_{10}H_{17}.NH_2$, boiling at 198—199°, the hydrochloride of which, when heated, splits into ammonium chloride and a hydrocarbon *thujene*, apparently possessing the constitution $C_{10}H_{16}$, but having none of the properties of a terpene. It boils at 172—175°, has sp. gr. 0·840 at 20° and $n_D = 1{\cdot}4761$. Thujone, when oxidised with permanganate, yields two isomeric thujoneketonic acids, and melting at 75—76°, and *β*°, at 78—79°. The latter, when distilled, yields methylheptylene ketone, $CH_3{\cdot}CO{\cdot}C_7H_{13}$.

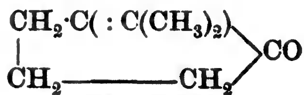
Tanacetone, $C_{10}H_{16}O = C_8H_{13}{\cdot}CO{\cdot}CH_3$, is a camphor-like substance occurring in the oils of tansy (*Tanacetum vulgare*),

sage, absinth, and thuja, and probably has the constitution given below. It is an oil boiling at 84·5° under 13 mm. pressure, dissolves in alcohol and ether but not in water, has sp. gr. = 0·9126 at 20°, n_D = 1·4495, and rotation = + 38½° in a length of 2 dm. It gives the usual derivatives, and the hydrochloride of the amine $C_8H_{13}·CH(NH_2)·CH_3$, itself prepared by reducing the oxime $C_8H_{13}·C(:NOH)·CH_3$ obtained directly from tanacetone, yields a terpene, *tanacetene*, $C_{10}H_{16}$, when distilled. This boils at 60—63°, under 14 mm. pressure, has sp. gr. = 0·8408 at 20°, n_D = 1·476, and seems to contain 2 ethylene-bonds. When treated with alkaline hypobromite tanacetone yields bromoform (reaction for $·CO·CH_3$ group) and tanacetogenic acid, $C_8H_{13}·COOH$. When oxidised with permanganate it yields tanaceto-carboxylic acid in two (physically?) isomeric modifications, identical


tanacetone


tanacetocarboxylic acid

with the α and β thujoneketonic acids of Wallach (see preceding paragraph). If this acid is treated with hypobromite, bromoform is obtained, and the $·CO·CH_3$ group is converted into ·COOH, tanacetogenic dicarboxylic acid being formed. This, when fused with potash, yields pimelic acid $COOH·CH_2·CH(CH(CH_3)_2)·COOH$. When distilled with soda-lime it yields tanacetophorone, a keto-pentamethylene derivative. Formulæ for several other terpene derivatives are also proposed in this paper. (**Semmler**, *Ber.*, xxv. 3343, 3513.)


tanacetophorone

Puleone, an isomer of camphor.—Puleone, $C_{10}H_{16}O$, is the chief constituent of oil of pennyroyal (*Mentha pulegium*). It is a colourless liquid with an odour of mint, boils at 222—223°, has sp. gr. 0·9482 at 0° and 0·9293 at 23°, $[\alpha]_D = +25·25$, $n_r = 1·4283$ and $n_b = 1·4997$. Chromic acid oxidises it to carbon dioxide, acetic acid, and propylsuccinic acid; phosphorus pentachloride converts it into a liquid, $C_{10}H_{15}Cl$, which when boiled splits into a cymene, $C_{10}H_{14}$, and HCl; it forms no additive product with bromine. (**Barbrer**, *Comptes Rendus*, cxiv. 126; *cp.* **Beckmann** and **Pleissner**, *Annalen*, cclxii. 1.) When oxidised with permanganate it yields β-methyladipic acid, $COOH·CH_2·CH_2·CH(CH_3)·CH_2·COOH$. (**Semmler**, *Ber.*, xxv. 3516.)

Menthol, $C_{10}H_{19}OH$, can be converted by phosphorus penta-

chloride into menthene, $C_{10}H_{18}$, which, with the same reagent, yields a chloride, $C_{10}H_{17}Cl$, and this, when reduced by heating with phosphorus and hydriodic acid, yields menthonaphthene. Menthol has thus been shown to be connected with the naphthenes; the particular naphthene obtained from it must have a ring of 6 carbon atoms, since menthol can be converted into cymene. It is also related to the terpenes, for terpene hydrate yields an alcohol, $C_{10}H_{19}OH$, much resembling menthol, and from menthol a hydrocarbon, $C_{10}H_{16}$, possessing the properties of a terpene, has been obtained. (**Berkenheim**, *Ber.*, xxv. 686.)

Tetrahydropinene, $C_{10}H_{20}$, has been obtained by heating pinene hydrochloride with phosphorus and hydriodic acid; it is probably hexahydrocymene. (**Wallach** and **Berkenheim**, *Annalen*, cclxviii. 225.)

The constitution of some terpenes has been investigated by spectroscopical methods. (**Brühl**, *Ber.*, xxv. 151.) The results lead to the assumption of one ethylene linkage in menthene, one para and one ethylene linkage in terebenthene (—pinene), and in tere- and borneo-camphene.

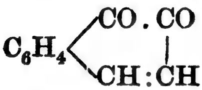
Sesquiterpenes, $C_{15}H_{24}$.—**Wallach** and **Walker** (*Annalen*, cclxxi. 285) make a first attempt to classify these substances. They divide them into two groups, the members of which contain respectively *two* and *one* ethylene bonds.

Cadinene is the most widely distributed of the sesquiterpenes, occurring in cadinum oil, etc. It boils at 274—275°; has sp. gr. 0·918 at 20°, $n_D=1·5065$, and $[\alpha]_D=-98·56°$; and remains optically active after treatment with hydrochloric acid; it contains two ethylene bonds. *Caryophyllene*, contained in oil of cloves, boils at 258—260°, and has sp. gr.=0·9085 at 15°, and $n_D=1·5009$. Under the influence of a mixture of sulphuric and acetic acids it takes up H_2O, forming the saturated alcohol $C_{15}H_{25}OH$, which yields a corresponding chloride and bromide, and with phosphoric anhydride is converted into a sesquiterpene,—*Clovene*, boiling at 261—263°, with sp. gr. 0·930 at 18°, and $n_D=1·5007$; this has only one ethylene bond. Another sesquiterpene is found usually accompanying cadinene, and yet another is formed from "patchouli camphor" by the loss of water. The sesquiterpenes can be reduced to hydrocarbons $C_{15}H_{28}$ by heating them with phosphorus and hydriodic acid.

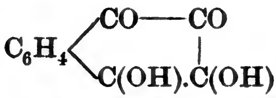
Other carbon cycloids.

Action of hypochlorous acid and bleaching powder on β-naphthoquinone.—Both hypochlorous acid and bleaching powder form *isonaphthazarin*, melting at 276°, a dihydroxy- β-naphthoquinone

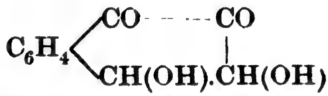
resembling naphtharazin in its properties. Under slightly different circumstances the δ-lactone of orthocarboxyphenylglyceric acid, melting at 204·5°, is formed. Reduced by heating with hydriodic acid and phosphorous, this yields orthocarboxyhydrocinnamic acid; when it is heated with hydrochloric acid, the δ-lactone of orthocarboxy-α-hydroxycinnamic (isocumarocarboxylic) acid, melting at 237°, is formed. When bleaching-powder is used, a compound intermediate between the naphthoquinone and the δ-lactone can be isolated; this is dihydroxydiketotetrahydronaphthalene. (**Bamberger** and **Kitschelt**, *Ber.*, xxv. 133, 888; **Zincke**, *Ber.*, xxv. 399, 1168.)



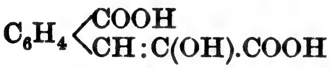
β-naphthoquinone



isonaphthazarin

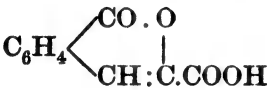


dihydroxydiketotetrahydronaphthalene

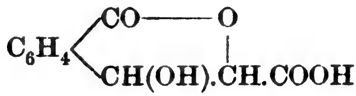


orthocarboxy-α-hydroxycinnamic acid

orthocarboxyphenylglyceric acid



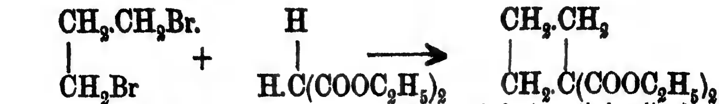
δ-lactone



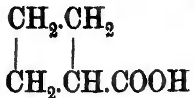
δ-lactone

Trimethylene.—**Brühl** (*Ber.*, xxv. 1952) concludes, from his determinations of the molecular refraction and dispersion of dichlorotrimethylene, that trimethylene is not an olefine, and that it contains no ethylene bonds.

Closed carbon chains.—Trimethylene bromide reacts with the sodium compound of ethyl malonate, forming ethyl tetramethylenedicarboxylate. The corresponding acid loses CO_2 when distilled, forming tetramethylene carboxylic acid. With this acid, as in the case of fatty acids, bromine forms an α-substitution derivative, in which the Br can be replaced by OH by the action of potash. By treating the acid chloride with zinc methide, or ethide, or with benzene in the presence of aluminium chloride, tetramethylene-methyl, -ethyl, and -phenyl ketones are formed. These behave just like similar compounds containing a saturated fatty, in place of the tetramethylene, residue. They form compounds with sodium hydrogen sulphite, yield oximes with hydroxylamine, and secondary alcohols, and occasionally also pinacones, when reduced with sodium amalgam; (when trimethylene methyl ketone is reduced, the trimethylene ring is broken and propyl-methyl carbinol, $CH_3.CH_2.CH_2.CHOH.CH_3$,



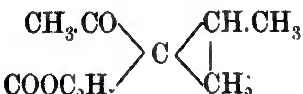
trimethylene bromide — ethyl malonate — ethyl tetramethylenedicarboxylate



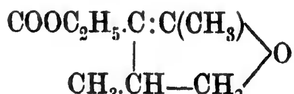
tetramethylenecarboxylic acid

tetramethylenemethyl ketone

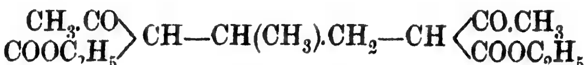
The action of propylene bromide on the sodium compounds of ethyl aceto- and benzoyl-acetate has been studied, and found to resemble that of ethylene bromide, but not to take place so readily. With ethyl aceto-acetate, $CH_3.CO.CH_2.COOC_2H_5$, propylene bromide, $CH(CH_3)Br.CH_2Br$ yields the three following substances :—



ethyl acetylmethyltrimethylenecarboxylate



ethyl dimethyldehydropentonecarboxylate

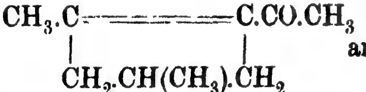


ethyl methyldiacetyladipate

The acid corresponding to the first of these, when boiled with water, loses CO_2, and the trimethylene ring breaks, a fatty alcohol, probably aceto-isobutyl alcohol,

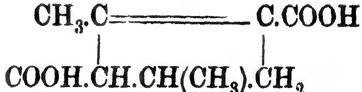
$$CH_3.CO.CH_2.CH(CH_3).CH_2OH,$$

being formed. The third substance yields when distilled :—



dimethyldihydropentenemethyl ketone

and



dimethyldihydropentenedicarboxylic acid

In the case of ethyl benzoylacetate a product analogous to the first of the three substances is alone formed, and its acid, benzoylmethyltrimethylenecarboxylic acid, when heated above 140°, loses CO_2 and forms, not an alcohol, but a ketone, benzoylmethyltrimethylene, $C_6H_5.CO.CH\left\langle\begin{matrix}CH.CH_3\\ |\\ CH_2\end{matrix}\right.$ (**W. H. Perkin**, jun., and **Stenhouse**, *J. Chem. Soc.*, 1892, 67.)

A red hydrocarbon.—**Graebe** (*Ber.*, xxv. 3146) has confirmed the observation that dibiphenylene, $\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}\!\!>C:C<\!\!\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}$ a hydrocarbon, obtained by passing fluorene $\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}\!\!>CH_2$ over heated lead oxide, or by heating it with chlorine, bromine, or sulphur, is red in colour. It has hitherto been assumed that all pure hydrocarbons are colourless.

Cycloids containing carbon and other atoms.

Syntheses of pyridine derivatives.—**Collie** and **Myers** (*J. Chem. Soc.*, 1892, 721), by acting on triacetic lactone ("Year Book," 1892, 183) with ammonia, have prepared 4 : 6-dihydroxy-2-methylpyridine. In this the two OH groups can be replaced by Cl by the action of phosphorus oxychloride, and when the resulting dichloromethylpyridine is heated with zinc-dust, Cl is replaced by H, and 2-methylpyridine, boiling at 128-129° is formed.

Gabriel (*Ber.*, xxv. 415), starting with phenol (1) and trimethylene chlorobromide (2), obtains phenyl-γ-chloropropyl ether (3), and converts this, by the aid of malonic acid (4), into phenoxypropylmalonic acid (5). This, when heated, loses CO_2 and forms δ-phenoxyvaleric acid (6), which, when heated with lead thiocyanate, forms the nitrile (7). By reducing the nitrile ε-phenoxyamylamine (8) is formed; its hydrochloride, when treated with soda, is converted into piperidine (hexahydropyridine) (9).

(1.) C_6H_5OH (2.) $BrCH_2.CH_2.CH_2.Cl$
(3.) $C_6H_5O.CH_2.CH_2.CH_2Cl$ (4.) $HCH(COOH)_2$
(5.) $C_6H_5O.CH_2.CH_2.CH_2.CH(COOH)_2$
(6.) $C_6H_5O.CH_2.CH_2.CH_2.CH_2.COOH$
(7.) $C_6H_5O.CH_2.CH_2.CH_2.CH_2.CN$
(8.) $C_6H_5O.CH_2.CH_2.CH_2.CH_2.CH_2.NH_2$
(9.) $\overline{CH_2.CH_2.CH_2.CH_2.CH_2.NH}$

Lipp (*Ber.*, xxv. 2190) has obtained Δ^2-tetrahydro-2-methylpyridine by acting on bromobutyl-methyl ketone

$$Br.CH_2.CH_2.CH_2.CH_2.CO.CH_3$$

with ammonia. On reduction it yields 2-methylpiperidine.

Synthesis of isoquinoline from naphthalene.—From β-naphthoquinone, itself obtained from naphthalene, orthocarboxy-α-

hydroxycinnamic acid can be obtained (p. 243). This, when treated with ammonia, yields isocarbostyrilcarboxylic acid, which, when heated, yields isocarbostyril; and this latter, when heated with zinc dust, yields isoquinoline. (**Bamberger** and **Kitschelt**, *Ber.*, xxv. 1138.)

$$C_6H_4\left\langle\begin{matrix}CO.NH\\ \quad\ \ |\\ CH:C.COOH\end{matrix}\right. \qquad C_6H_4\left\langle\begin{matrix}CO.NH\\ \quad |\\ CH:CH\end{matrix}\right. \qquad C_6H_4\left\langle\begin{matrix}CH:N\\ \quad |\\ CH:CH\end{matrix}\right.$$

isocarbostyrilcarboxylic acid — isocarbostyril — isoquinoline

Triazole, or *Pyrrodiazole,* $\left.\begin{matrix}N = CH\\ |\qquad\\ NH.CH\end{matrix}\right\rangle N$, has been prepared independently by **Andreocci** (*Ber.*, xxv. 225) and **Bladin** (*Ber.*, xxv. 174, 741). It melts at 120–121°, beginning to sublime before melting, and boils at 260°; dissolves readily in water and alcohol, less so in ether; has an odour of pyrrazole; forms copper, mercury, and silver compounds, and a crystallised hydrochloride.

Tetrazole, probably $\left.\begin{matrix}N = N\\ |\qquad\\ NH.CH\end{matrix}\right\rangle N$, has been prepared by **Bladin** (*Ber.*, xxv. 1411). It melts at 155°, beginning to sublime before melting, and dissolves readily in water, alcohol, acetone, and ethyl acetate, sparingly in ether, benzene and toluene. It has no basic properties, but reddens litmus paper, and gives silver and copper compounds which explode when heated.

Pyrazolones and Isopyrazolones.—Just as from ethyl acetoacetate, $C(CH_3)OH : CH.COOC_2H_5$, and phenylhydrazone, $NH(C_6H_5).NH_2$, phenyl-methylpyrazolone is formed, so from β-bromobutyric acid, $CH(CH_3)Br.CH_2.COOH$, a dihydrophenylmethyl*iso*pyrazolone is obtained, which, when oxidised with ferric chloride, yields phenyl-methylisopyrazolone. This gives isoantipyrine when the H of the NH group is replaced by CH_3, just as phenyl-methylpyrazolone gives antipyrine. (**Lederer**, *J. Pr. Chem.* [2], xlv, 83.)

$$C_6H_5.N\left\langle\begin{matrix}CO.CH\\ \quad \|\\ NH.C(CH_3)\end{matrix}\right. \qquad\qquad C_6H_5.N\left\langle\begin{matrix}C(CH_3):CH\\ \qquad\quad |\\ \qquad -CO\end{matrix}\right.$$

phenyl-methylpyrazolone — phenyl-methylisopyrazolone

Pyrazolone itself has been prepared by heating its carboxylic acid, which is obtained when the hydrate of hydrazine is treated with ethyl oxalylacetate.

$$\underset{\text{hydrazine}}{\begin{matrix} NH_2 \\ | \\ NH_2 \end{matrix}} + \underset{\text{oxalylacetic acid}}{\begin{matrix} OC(COOH){\cdot}CH_2 \\ \quad\quad\quad | \\ HO{\cdot}CO \end{matrix}} = 2H_2O + \underset{\text{pyrazolonecarboxylic acid}}{N\begin{cases} C(COOH){\cdot}CH_2 \\ \quad\quad\quad\quad | \\ NH \text{———} CO \end{cases}}$$

It is a colourless oil, boiling at 77°, and having an odour of mice. (**Rothenburg**, *Ber.*, xxv. 3441.)

Indoxazenes.—If an aromatic oxime has a halogen atom in the ortho position, this atom is given off on heating in combination with the H of the NOH group, and an indoxazene is formed; *e.g.*—

$$\underset{\text{orthobromobenzophenone oxime}}{\begin{matrix} CH : CH{\cdot}CBr & HON \\ | \quad\quad \| & \| \\ CH : CH{\cdot}C \text{———} & C{\cdot}C_6H_5 \end{matrix}} = HBr + \underset{\text{phenylindoxazene}}{\begin{matrix} CH : CH{\cdot}C{\cdot}O{\cdot}N \\ | \quad\quad \| \quad \| \\ CH : CH{\cdot}C - C{\cdot}C_6H_5 \end{matrix}}$$

Phenylindoxazene is an unstable white solid, melting at 83° to 84° and boiling at 331° to 336°. The only derivative prepared was a dinitro one. (**V. Meyer** and others, *Ber.*, xxv. 3291, 3297.)

Imidazole, identical with glyoxaline.—**Marckwald** (*Ber.*, xxv. 2534) has prepared many derivatives of imidazole. Imidazole itself he has synthesised, and shown it to be identical with glyoxaline, the substance obtained by the action of ammonia on glyoxal, CHO.CHO. The hitherto missing experimental proof of the formula of glyoxaline is thus supplied:—Amido-acetal hydrochloride (1), when treated with potassium thiocyanate, yields acetal thiourea, amido-acetal thiocyanate (2) being doubtless formed as an intermediate product. The thiourea, when heated with dilute sulphuric acid, loses alcohol and forms μ-imidazolyl mercaptan, which, when oxidised, yields imidazole and sulphuric acid.

(1.) $NH_2.CH_2.CH(OC_2H_5)_2$ (2.) $SCN.NH_3.CH_2.CH(OC_2H_5)_2$

$$\underset{\text{acetal thiourea}}{SC\begin{cases} NH_2 \\ NH.CH_2.CH(OC_2H_5)_2 \end{cases}} \quad \underset{\mu\text{-imidazolyl mercaptan}}{\begin{matrix} HS.C.NH.CH \\ \| \quad\quad \| \\ N\text{——}CH \end{matrix}} \quad \underset{\text{imidazole (glyoxaline)}}{\begin{matrix} CH.NH.CH \\ \| \quad\quad \| \\ N\text{———}CH \end{matrix}}$$

Piperazines—**Bischoff** (*Ber.* xxv. 2940; *see* also this vol., p. 253) has prepared piperazines belonging to the following four classes $\left(R = C_6H_5,\ C_7H_7\ (p \text{ and } o),\ C_{10}H_7\ (\alpha \text{ and } \beta)\right)$,—

$$NR\left\langle\begin{matrix} CH_2.CH_2 \\ CH_2.CH_2 \end{matrix}\right\rangle NR \quad \left[N\left\langle\begin{matrix} C(\alpha).C(\beta) \\ C(\delta).C(\gamma) \end{matrix}\right\rangle N\right] \quad NR\left\langle\begin{matrix} CH_2.CO \\ CH_2.CH_2 \end{matrix}\right\rangle NR$$

1. Without oxygen. 2. Monacipiperazine.

$$\underset{\alpha\ \beta}{NR\left\langle\begin{matrix} CO.CO \\ CH_2.CH_2 \end{matrix}\right\rangle NR} \quad \underset{\alpha\ \gamma}{NR\left\langle\begin{matrix} CO.CH_2 \\ CH_2.CO \end{matrix}\right\rangle NR} \quad \underset{\alpha\ \delta}{NR\left\langle\begin{matrix} CO.CH_2 \\ CO.CH_2 \end{matrix}\right\rangle NR}$$

3. Diacipiperazines

$$NR\left\langle\begin{matrix}CO.CO\\CO.CO\end{matrix}\right\rangle NR$$

4. Tetracipiperazine

Alkaloids.

Hyoscyamine has been found to occur in extract of common lettuce made from the flowering plant, and is doubtless the cause of the well-known sedative effect of lettuce. It only exists to the extent of 0·02 per cent. in the extract, and the plant cannot contain more than 0·001 per cent. (**Dymond**, *J. Chem. Soc.*, 1892, 90.)

Aconitine is a crystalline alkaloid occurring in the true *Aconitum napellus*, together with three non-crystalline ones, *aconine*, *napelline*, and *homonapelline*, the former of which, however, yields a crystallised hydrochloride, $C_{26}H_{41}NO_{11}, HCl + 2H_2O$. Aconitine is benzoylaconine, $C_{26}H_{40}$ (C_6H_5CO) NO_{11}, for when hydrolised it yields nothing but aconine and benzoic acid, and it is formed when pure aconine is heated with ethylbenzoate. (**Dunstan** and others, *J. Chem. Soc.*, 1892, 385.)

Corydaline when pure has the composition $C_{22}H_{29}NO_4$, and contains four (OCH_3) groups, since with H1 it yields 4 mols. $CH_3 1$. It also appears to contain a pyridine and a benzene ring. (**Dobbie** and **Lauder**, *J. Chem. Soc.*, 1892, 244, 605; *cp.* **Freund** and **Josephy**, *Ber.*, xxv. 2411.)

Chrysanthemine, $C_{14}H_{28}N_2O_3$, has been obtained from chrysanthemum flowers; it is a colourless syrup which, when kept in a vacuum, partially crystallises, and is optically inactive and physiologically innocuous. It appears to have the constitution

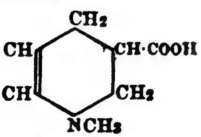
$$\begin{array}{l}N(CH_3)_3.CH_2.C(CH_3).CH_2.CH_2OH.\\ \,|\qquad\qquad\qquad\;\; |\\ O\text{——}CO\text{——}C_5NH_9\end{array}$$

When boiled with very strong aqueous alkali it yields hexahydropyridinecarboxlyic acid (probably the γ acid), γ-hydroxybutyric acid, trimethylamine, carbon dioxide and hydrogen, according to the equation—

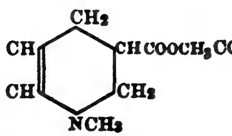
$$\begin{aligned}C_{14}H_{28}N_2O_3 + 4KOH + H_2O\\ = C_5H_{10}N.COOK + CH_2OH.CH_2.CH_2.COOK\\ + N(CH_3)_3 + K_2CO_3 + 4H_2.\end{aligned}$$

(**Zuco**, *Gazzetta*, xxi. [1], 516.)

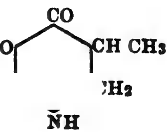
Areca nuts contain, besides choline, the following four alkaloids :—



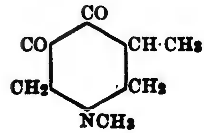
arecaidine



arecoline



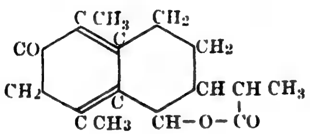
guvacine

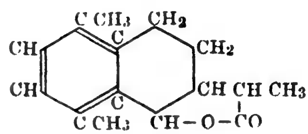


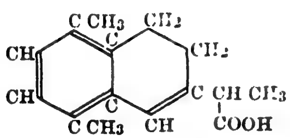
arecaïne

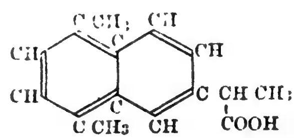
Arecaïdine, $C_7H_{11}NO_2 + H_2O$, is shown to be methyltetrahydronicotinic (pyridine β-carboxylic) acid by a synthesis from nicotinic acid; *arecoline*, $C_8H_{13}NO_2$, is its methyl ester. *Guvacine*, $C_6H_9NO_2$, is a secondary base, for it forms a nitroso compound; when distilled with zinc dust it yields β-methylpyridine. Its methyl derivative is identical with *arecaine*, $C_7H_{11}NO_2 + H_2O$. (**Jahns**, *Arch. Pharm.*, ccxxix. 669.)

Santonine yields with hydroxylamine santoninoxime, which is reduced by zinc dust and sulphuric acid to santoninamine. This, when treated with nitrous acid, yields hyposantonine, a lactone, which when heated with hydrochloric or hydriodic acid is converted into dihydrosantic acid, from which, by oxidation with iodine, santic acid may be obtained.


santonine


hyposantonine


dihydrosantic acid


santic acid

In support of these formulæ are the facts that santic and dihydrosantic acids yield ethyldimethylnaphthalene when distilled with baryta, and santonin and dihydrosantic acid yield paradimethylphthalic acid when oxidised with permanganate. (**Gucci** and **Grassi-Cristaldi**, *Gazzetta*, xix. 367; xxii. [1], 1.)

Hydrastine.—An exhaustive paper by **Freund** on this alkaloid has appeared (*Annalen*, cclxxi. 311); we can give here no more than the final result. Hydrastine $C_{21}H_{21}NO_6$, when oxidised with dilute nitric acid, yields hydrastinine and opianic acid, behaving thus like narcotine;

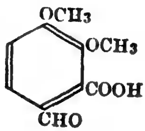
$$\underset{\text{hydrastine}}{C_{21}H_{21}NO_6} + H_2O + O = \underset{\text{opianic acid}}{C_{10}H_{10}O_5} + \underset{\text{hydrastinine}}{C_{11}H_{13}NO_3}$$

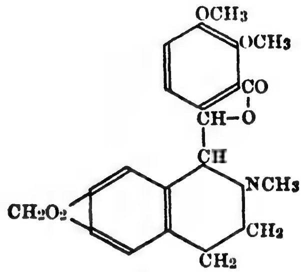
$$\underset{\text{narcotine}}{C_{22}H_{23}NO_7} + H_2O + O = \underset{\text{opianic acid}}{C_{10}H_{10}O_5} + \underset{\text{cotarnine}}{C_{12}H_{15}NO_4}$$

Hydrastinine contains an aldehyde group; when oxidised with

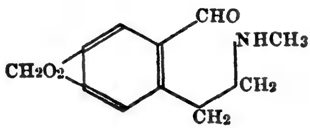
dilute nitric acid it yields apophyllenic acid; by oxidation with permanganate, and subsequent further treatment, it is converted into hydrastic acid, which was shown to have the formula given below. Hydrastinine, which can be converted into both apophyllenic and hydrastic acids, and hydrastine, which yields hydrastinine and opianic acid, have therefore the formulae given below. Hydrastine is thus, like papaverine, narcotine, and berberine, a derivative of isoquinoline.

opianic acid

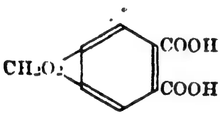




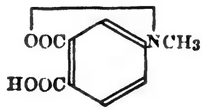
hydrastine



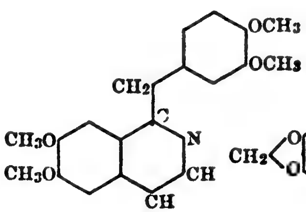
hydrastinine



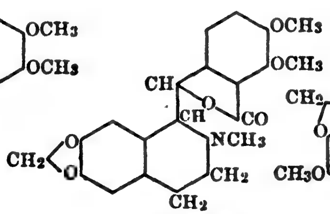
hydrastic acid



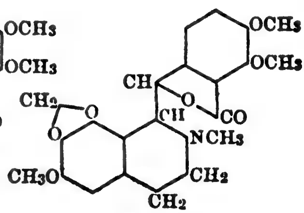
apophyllenic acid



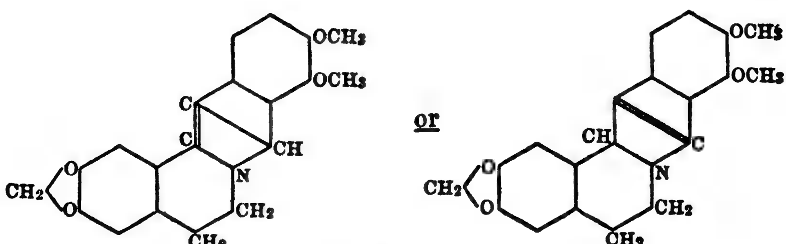
papaverine



hydrastine



narcotine



berberine

Adenine and hypoxanthine.—These two nuclein bases resemble uric acid in that, when hydrolysed, they yield ammonia, carbon dioxide, formic acid, and glycocine. Adenine further resembles uric acid in containing an alloxan nucleus, for bromadenine, when oxidised with hydrochloric acid and potassium chlorate, yields alloxan, urea, and oxalic acid. (**Krüger**, *Zeit. Physiol. Chem.*, xvi. 160, 329; **Bruhns** and **Kossel**, *Ibid.*, 1.)

Glucosides.

Frangulin has the composition $C_{21}H_{20}O_9$, and its hydrolysis is represented, as Schwabe supposed, by the equation

$$\underset{\text{frangulin}}{C_{21}H_{20}O_9} + H_2O = \underset{\text{emodin}}{C_{15}H_{10}O_5} + \underset{\text{rhamnose}}{C_6H_{12}O_5}$$

(**Thorpe** and **Miller**, *J. Chem. Soc.*, 1892, 1.)

Geometrical Isomerism.

Hantsch and **Kraft** (*Ber.*, xxiv. 3511) claim to have prepared two *isomeric hydrazones* $C_6H_5—C(:N·NHC_6H_5)—C_6H_4·CH_3$ of phenylanisyl ketone. The existence of isomerism among the hydrazones similar to that among the oximes shows that this isomerism is not caused by the nature of the oximido group, as Auwers and V. Meyer suppose, but by the nature of the nitrogen-tation itself (*cp.* "Year-Book" for 1891, 217). **Auwers** and **Meyer** maintain, however (*Ber.*, xxiv. 4225), that their hypothesis is equally capable of accounting for this isomerism among the hydrazones, the first instance of which was discovered, not by Hantsch and Kraft, but in Meyer's laboratory by Fehrlin and Krause (*Ber.*, xxiii. 1574, 3617).

Werner (*Ber.*, xxv. 27.) shows that the two ethylbenzhydroximic acids (Lossen's α and β ethylbenzhydroximic acids) are really isomeric, for they yield different acetyl and paranitrobenzyl derivatives. The isomerism is geometrical, and is represented by the following formulæ:—

$$\begin{array}{c} C_6H_5—C—OC_2H_5 \\ \| \\ HO—N \end{array} \qquad \begin{array}{c} C_6H_5—C—OC_2H_5 \\ \| \\ N—OH \end{array}$$

ethylsynbenzhydroximic acid (α) ethylantibenzhydroximic acid (β)

Chalanay and **Knoevenagel** have discovered two isomeric symmetrical diphenylsuccinonitriles. These can be prepared by heating a mixture of benzyl and benzal chlorides with potassium cyanide, or by heating benzylcyanide with mandelonitrile in presence of potassium cyanide.

$$C_6H_5 \cdot CH_2Cl + C_6H_5CHCl_2 + 3KCN = 3KCl + HCN + \begin{array}{l} C_6H_5 \cdot CH \cdot CN \\ \quad\;\; | \\ C_6H_5 \cdot CH \cdot CN \end{array}$$

$$C_6H_5 \cdot CH_2CN + C_6H_5 \cdot CHOH \cdot CN = H_2O + \begin{array}{l} C_6H_5 \cdot CH \cdot CN \\ \quad\;\; | \\ C_6H_5 \cdot CH \cdot CN \end{array}$$

Both modifications are optically inactive, the α-variety by intramolecular, the β by intermolecular compensation, as in the case of racemic and mesotartaric acids respectively. (*cp.* "Year-Book" for 1891, p. 210.) The α modification (melting at 160°) is converted into the β (melting at 229°) when heated with strong hydrochloric acid. (*Ber.*, xxv. 289.)

Auwers and **Kauffmann** (*Ber.*, xxv. 3221) have observed similar isomerism among the derivatives of dimethylglutaric acid—

$$COOH \cdot \mathbf{C}\ (CH_3)\ (OH) - CH_2 - \mathbf{C}\ (CH_3)\ (OH) \cdot COOH\ ;$$

these exist in two forms, corresponding to racemic and mesotartaric acids.

Matthews (*J. Chem. Soc.*, 1892, 103), by exposing a mixture of chlorobenzene and sodium hypochlorite to bright sunlight, has obtained α monochlorobenzene hexachloride (melting at 146°), mixed with a little of the β modification (melting at 260°), which has been prepared previously by the action of chlorine on sulphobenzide in sunlight..

L. Meyer, jun. (*Ber.*, xxv. 3121 ; *cp.* **Erlenmeyer**, *Annalen*, cclxxi. 137), has separated phenyldibromopropionic acid,

$$C_6H_5 \cdot CHBr \cdot CHBr \cdot COOH,$$

by crystallising its strychnine-salt from alcohol, into a dextro and a laevo-rotatory variety with rotation $[\alpha]_D = +14{\cdot}0°$ and—13·1° respectively.

Marckwald (*Ber.*, xxv. 3098) shows that two isomeric thiosemicarbazides are formed when isothiocyanates are brought together with phenylhydrazine. For example, diphenylthiosemicarbazide, $C_6H_5 \cdot NH \cdot C(SH) : N \cdot NHC_6H_5$, forms α and β modifications, melting at 139° and 176° respectively. The α-modifications are very unstable, and are converted into the β ones when fused, or when a trace of hydrochloric acid is added to their alcoholic solution.

Schall and **Paschkowetzky** (*Ber.*, xxv. 2880) find that when carbodiphenyl-and-diparatolyl-imide are distilled under reduced pressure, a mixture of two isomers is obtained from each. The two

varieties of carbodiparatolylimide thus obtained melt at 49—60° and 148—149°, respectively; of carbodiphenylimide, $C(:NC_6H_5)_2$, one is liquid, the other melts at 158—160°. This isomerism is supposed to be of a new kind, and is represented by the adjoined two formulae.

$$\begin{array}{c} RN \\ \| \\ C \\ \| \\ NR \end{array} \qquad \begin{array}{c} NR \\ \| \\ C \\ \| \\ NR \end{array}$$

a γ Diacipiperazines (see p. 247) exist in a para and an anti modification, the former having the higher melting-point, and being transformable into the latter. (**Nastvogel** and **Hanstörfer**, *Ber.*, xxiii. 2012; xxiv. 2298.) **Tigerstedt** (*Ber.*, xxv. 2919) has prepared several by the action of alcoholic potash on bromanalides,—toluidides, etc.

$$C_6H_5NH \begin{array}{l} \diagup CO \cdot CHBr(CH_3) \diagup \\ \;\; CHBr(CH_3) \cdot CO \end{array} NHC_6H_5$$

bromopropionanilide (2 mols.)

$$= 2HBr + C_6H_5 \left\langle \begin{array}{l} CO \cdot CH(CH_3) \\ CH(CH_3) \cdot CO \end{array} \right\rangle NC_6H_5$$

diphenyl-αγ-diaci-βδ-dimethylpiperazine

Miscellaneous.

Alkali manufacture.—An important extension of the ammonia-soda process is now in operation at the works of Messrs. Brunner, Mond and Co., by means of which it is at last possible to obtain the chlorine of the salt employed in a useful form, bleaching powder, instead of as hitherto in a waste product, calcium chloride. The ammonium chloride solution, instead of being boiled with lime as formerly, is made to yield crystals by freezing it in an ammonia refrigerating apparatus; this crystallised ammonium chloride is decomposed by heating into ammonia and hydrochloric acid, and the mixture of these is passed over heated magnesium oxide, which decomposes the hydrochloric acid with formation of magnesium chloride, while the ammonia passes on and is collected. The magnesium chloride is then heated, and air is passed over it; by this means the oxide is regenerated, and chlorine set free. The chlorine is finally converted into bleaching powder by passing it over slaked lime, the lime having been obtained from an earlier operation. There are thus no waste products, and the equation—

$$2\,NaCl + CaCO_3 + O \text{ (from the air)} = Na_2CO_3 + CaCl_2O$$

is realised as the final result of the following separate processes:—

$$\mathbf{2\,NaCl} + 2\,NH_3 + 2\,CO_2 + 2\,H_2O = 2\,NaHCO_3 + 2\,NH_4Cl$$
$$2\,NaHCO_3 = \mathbf{Na_2CO_3} + CO_2 + H_2O.$$
$$2\,NH_4Cl = 2\,NH_3 + 2\,HCl.$$
$$2\,HCl + MgO = MgCl_2 + H_2O.$$
$$MgCl_2 + \mathbf{O}\ \text{(from the air)} = MgO + Cl_2.$$
$$\mathbf{CaCO_3} = CaO + CO_2.$$
$$CaO + H_2O = Ca(OH)_2.$$
$$Ca(OH)_2 + Cl_2 = \mathbf{CaCl_2O} + H_2O.$$

In the above equations the substances which are formed in one operation and used in another are printed in ordinary type. The actual raw material of the process and the finished products are printed in bolder type. (*The Times*, Oct. 21, 1892.)

Glass for chemical utensils.—The best glass for such purposes has the following composition:—

According to—	Silica.		Lime.		Alkali.
Weber and Sauer	8	:	1	:	1·5
Mylius and Fœrster	7·2	:	1	:	1·1

Alkalies attack glass more than water does, and water more than acids. (*Ber.*, xxv. 70, 97, 2494.)

Origin of colour.—**Armstrong** (*Proc. Chem. Soc.*, 1888, 27, 1892, 101, 103, 143, 189, 194), and **Hartley** (*Ibid.*, 1892, 188) have advanced the hypothesis (which has, indeed, hardly found acceptance), that colour in organic compounds is correlated with a *quinonoid* structure, the term including such compounds as benzil, and it being also understood that in the case of closed chain compounds at least one of the quinonoid carbon atoms is associated with a dyadradical, and the ring itself is unsaturated.

Acetyl derivatives in urine after feeding with aldehydes.—Rabbits and dogs, if fed with furfuraldehyde, excrete furfuracrylic acid, a Perkin's-synthesis taking place within the body.

$$\underset{\text{furfuraldehyde}}{C_4H_3O{\cdot}CHO} + \underset{\text{acetic acid}}{H_2CHCOOH} = H_2O + \underset{\text{furfuracrylic acid}}{C_4H_3O{\cdot}CH : CH{\cdot}COOH.}$$

If rabbits are fed with metanitrobenzaldehyde, a synthesis with acetic acid also occurs, but of a different kind, metacetamidobenzoic acid being formed.

$$\underset{\text{amidobenzoic acid}}{COOH{\cdot}C_6H_4{\cdot}NHH} + \underset{\text{acetic acid}}{HO{\cdot}CO{\cdot}CH_3}$$
$$= H_2O + \underset{\text{acetamidobenzoic acid}}{COOH{\cdot}C_6H_4{\cdot}NH{\cdot}CO{\cdot}CH_3.}$$

With paranitrobenzoic aldehyde the analogous para com-

pound was formed, and appeared in the urine in molecular combination with paranitrobenzoic acid. (**Cohn**, *Ber.*, xxv. 2457.)

Laws of nutrition.—**Pflüger**, as the result of an exhaustive series of experiments, arrives at the following conclusions :—(1) Albumen, when supplied in sufficient quantity, is the sole source of muscular energy, and is only replaced, so far as this function is concerned, by fats and hydrocarbons, when it is itself supplied in insufficient amount. (2) Fat is not formed from albumen, but from fats and hydrocarbons supplied in excess of the bodily need. (*Arch. f. d. ges. Physiol.*, l. 98, 330, 396; li. 229, 317; lii. 1, 239.)

Molecular weight of peptones.—This is comparatively low, two samples having molecular weights, as determined cryoscopically, of 555–529, and 317–344 respectively, and that of the benzoyl derivative of the latter being 500–600. (**Ciamician** and **Zanetti**, *Atti. d. R. Acc. d. Lincei.*, 1892, i. 229.)

Assimilation of free nitrogen by plants.—Much has been published on this subject. The general result is that, while various plants are capable of absorbing free nitrogen, only the leguminous ones do so to any great extent. And upon these nitrogenous manures have little effect, scarcely even increasing the carbon assimilation. In the case of other plants nitrogenous manures largely increase the assimilation of carbon, but scarcely affect that of nitrogen. (**Lawes** and **Gilbert**, *Jour. Roy. Agri. Soc.* [3], 11, 657; **Frank**, *Landw. Jahrb.*, xxi. 1; **Immendorf**, *Ibid*, 281; **Schloesing** and **Laurent**, *Comptes Rendus*, cxiii. 776; *Ann. Inst. Pasteur*, vi. 65; **Beyerinck**, *Meded. Konink. Akad. Wetens* [3], viii. 460.)

Starch from formaldehyde.—If plants which have been deprived of starch, and placed in an atmosphere free from carbon dioxide, are fed with the sodium-hydrogen sulphite compound of formaldehyde, they form starch, but only when exposed to light. (**Bokorny**, *Landw. Jahrb.*, xxi. 445.)

Chemical nomenclature.—An international congress met at Easter in Geneva to formulate a systematic nomenclature for organic substances. Terminal syllables were largely adopted to express chemical constitution, the same syllable always indicating membership of some one series, or presence of the same group of atoms—*e.g.*, *-ane* for fatty hydrocarbons, *-al* for -CHO. A few of the old trivial names were retained, and it was proposed to retain the old nomenclature side by side with the new—the latter being intended chiefly for purposes of references. At this congress only fatty derivatives were dealt with. (*Nature*, xlvi. 56.) **Armstrong** suggests the term *cycloids* for compounds containing groups of atoms united in a ring, and has proposed a nomenclature for them. (*Proc. Chem. Soc.*, 1892, 127.)

GEOLOGY.

MINERALOGY AND PETROLOGY.

BY G. T. PRIOR, M.A.

Mineralogy.

BY no means the least noteworthy event of the year in the mineralogical world has been the appearance of the new edition (6th) of Dana's standard text-book, "A System of Mineralogy." The new work has been entirely rewritten and considerably enlarged by **Prof. E. S. Dana.** The crystallographic portion of the subject receives much fuller treatment than in the earlier editions. One of the most satisfactory changes to be noticed is the adoption throughout the book of the Miller notation in the symbols of the crystal faces. The system of classification remains practically the same as in the last edition, the predominant position being given to chemical, the next place to crystallographic, the third to the different physical characters.

In connection with the subject of classification the "Systematic Mineralogy, based on a Natural Classification," of the late **Dr. T. Sterry Hunt,** deserves mention from the interest which attaches to such an attempt at bringing Mineralogy into conformity with the other natural sciences. A natural history classification, founded on that of Mohs, was originally adopted by Dana in his "Mineralogy," but in the third edition the whole system was rejected as essentially false to nature, and was replaced by the present chemical classification.

Dr. Hunt's classification is an attempt to combine the natural historical and chemical methods. In this system the mineral kingdom is divided into four classes:—metallaceæ, halidaceæ, oxydaceæ, and pyricaustaceæ. The first class, which is subdivided into metallometallata and spathometallata, includes the metals and their compounds with the sulphur and arsenic groups of elements. The halidaceæ contain four orders, the fluorinea, the chlorinea, brominea, and iodinea. The oxydaceæ include the oxides, silicates, etc. The last class, the pyricaustaceæ, consists of the different forms of carbon and organic bodies, such as the resins, coal, etc.

Crystallography and physical mineralogy.

A little book which is calculated to revolutionise the method of teaching of physical optics as applied to crystallography is **L. Fletcher's** tract on double refraction, "The Optical Indicatrix and the Transmission of Light in Crystals." Fresnel's theory of double refraction has long been regarded as dynamically unsound, and although experiment has proved the substantial accuracy of the wave-surface deduced from it, yet recent investigations have shown that the theory of vibration in an incompressible ether with varying elasticity is untenable. According to the modern theories of **Lord Kelvin** and **Mr. Glazebrook**, an elastic luminiferous ether is to be regarded as compressible, with effective elasticity constant, but with effective density variable for different media, and, in the case of a doubly refracting body, for different directions in the same medium.

The abandonment of Fresnel's process, and the adoption of these new views, should lead to the disappearance from scientific literature of all such terms as ellipsoid of optic elasticity, axes of optic elasticity, etc., which are now in common use.

The author's treatment of the problem of the transmission of light in crystals is, however, entirely independent of any theory as to the nature of the vibration which constitutes light. Huyghens' construction stands as the basis of the method. This geometrical construction for finding the path of the two rays in a uniaxal crystal such as calcite is independent of all theories of vibration; it is a direct deduction from experimental facts, and expresses undoubtedly a law of Nature. Now the characters of a ray of plane polarised light may be geometrically represented by a finite straight line, and a point off the line; the direction of the ray is along the perpendicular from the point upon the line, its velocity is inversely as the length of the line, and its plane of polarisation is normal to the line. From Huyghens' construction then it easily follows that for uniaxal crystals the finite straight lines characteristic of the rays are all normal to the extraordinary wave-surface, viz., the spheroid. Any point on the spheroid therefore corresponds to a ray transmissible in the direction of the perpendicular from the centre upon the normal at the point, and according to the modern views of the ether the normal is the direction of vibration of the ray. Accordingly from this spheroid the whole optical behaviour of a uniaxal crystal can be deduced. To such a surface of reference the author gives the name of "optical indicatrix," and extends its use to biaxal crystals by the beautifully simple generalisation which assumes

that for such crystals the surface, instead of a spheroid, is an ellipsoid with three unequal axes.

H. A. Miers, by treating with acid the marl containing orpiment of Tajowa, has succeeded in extracting from the clayey residue beautiful minute crystals of this mineral, which have sharply defined edges and are nearly transparent. The results of the optical determinations were in complete accordance with the requirements of orthorhombic symmetry.

This is of interest in view of the fact that Drude's experiments on the reflection of light from the isomorphous mineral stibnite indicated that it possessed the symmetry of the mono-symmetric, and not of the orthorhombic system. (*Min. Mag.*, x. 24.)

F. Rinne gives a further contribution to our knowledge of the zeolites belonging to the Heulandite and Desmine (Stilbite) groups. By a different mode of orientation of the crystals he shows the close crystallographic relation which the three members of the first group (heulandite, brewsterite, and epistilbite) bear to those of the second (harmotome, phillipsite, and desmine), and also to the felspars. The monoclinic heulandite is related to the triclinic desmine as orthoclase to microcline.

The author has continued his interesting experiments on the behaviour of these minerals on heating. He finds, contrary to Klein, that brewsterite behaves in a precisely similar way to heulandite. On heating to 200°, by a gradual change of the axes it becomes orthorhombic, and remains so on cooling so long as water is excluded, but in contact with water it returns at once to its original optical condition. On heating above 200° the mineral again becomes monoclinic. When strongly heated the double refraction becomes weak, and after this state has been produced the mineral no longer returns to its original condition on cooling. Epistilbite and desmine required to be heated up to the point of weak double refraction before orthorhombic symmetry was obtained; while harmotome and phillipsite still remained triclinic at that point.

The author concludes that these six minerals are truly distinct species, but that they form a natural group exhibiting a gradation in properties. (*Neues. Jahrb.*, 1892, i. 12.)

H. Laspeyres has made a thorough chemical and crystallographic examination of the rare mineral beyrichite, and shows that it bears the same relation to millerite as augite to uralite. (*Zeits. Kryst.*, xx. 535.)

C. Klein contributes an elaborate monograph on the crystal system of apophyllite and the influence of pressure and heat on its optical properties.

The anomalous optical characters of the mineral are attributed to the intimate isomorphous mixture of an optically positive substance with a negative one. (*Sitzungsber. Akad. Wiss. Berlin*, 1892 ii., 65.)

A. Lacroix notes the relation existing between the form of the crystals of Andalusite in Ariège and the nature of the formations in which they occur. He finds that they are absolutely characteristic one of the other. (*Comptes Rendus*, cxiv. 955.)

Somewhat discordant views have been expressed on the optical properties of chalcedony. **Michel Levy** and **Munier-Chalmas** throw light upon this subject by their examination of some varieties of concretionary silica from the Paris basin. They distinguish three varieties which they name chalcedony, quartzine, and lutecine. These are different forms of one mineral which is biaxal, with optic axes separated from 20° to 35° about a positive bisectrix. They consist of pure silica having a density near to 2·6, but differ between themselves in the direction of elongation of the fibres. (*Bull. Soc. Fr. Min.*, xv. 159.)

Chemical mineralogy.

The results of an attempt at determining the constitution of the natural silicates which have been appearing in a series of papers by **F. W. Clarke** and **E. A. Schneider** must excite general interest. The authors endeavour to imitate if possible the methods of organic chemistry, and to devise reactions analogous to those by which the constitution of complex organic compounds are determined. The task appears almost hopeless when the fact of the present impossibility of measuring the molecular weight of silicates is considered. The second great difficulty, however, of the lack of plasticity in the material under investigation, has been found to be less formidable than at first supposed.

Members of the mica and chlorite group, together with a few other magnesium silicates, as talc, serpentine, and olivine, have been the subjects of experiment.

The crucial reaction, first brought forward by the authors in 1890, by which the distribution and character of the hydroxyl in these hydrated silicates may be determined, consists in subjecting them to the action of dry hydrochloric acid, when heated to a temperature of about 400°. Silicates which are strongly affected by this treatment are assumed to contain the grouping—Mg—OH. The reaction was at first supposed to be quantitative, but later experiments have shown that at present it can only be trusted qualitatively.

A second process by which light can be thrown upon the

constitution of silicates consists in determining the products of decomposition resulting from ignition.

Application of the two processes to members of the chlorite group shows that these silicates contain the group—Mg—OH, and that they split up on ignition into an insoluble portion, having the composition of spinel, and a soluble portion, expressible as a mixture of olivine and magnesian garnet; minerals which, according to the authors, are amongst the commonest progenitors of the chlorite group. They consider that their results tend to establish their hypothesis that the more complex silicates are merely substitution derivatives of normal salts. In the case of the chlorites they rely upon the "spinel reaction" to render Tschermak's theory of this group untenable; for his typical ortho-chlorite series is supposed to consist of mixtures of two end products, serpentine and amesite. Now serpentine on ignition splits up into soluble olivine and insoluble enstatite, but, as we have seen, in the case of chlorites the insoluble residue on ignition contains no enstatite but only spinel. (*Amer. Jour. Sci.*, xl. 303, 405, 452; and xliii. 190, 378.)

The chemical composition of iolite has never been satisfactorily established, for the reason that the state of oxidation of the iron has not hitherto been determined. **O. C. Farrington** has analysed exceptionally pure specimens of the mineral from Guildford, Conn., and gives the formula $H_2O.4(Mg.Fe)O$, $4Al_2O_3$, $10SiO_2$, all the iron being in the ferrous state. (*Amer. Jour. Sci.*, xliii. 13.)

A new and interesting variety of herderite from Hebron, Maine, which contains scarcely any fluorine, is described by **H. L. Wells** and **S. L. Penfield.** The result of analysis confirms the formula previously given by Penfield and Harper for this mineral, and supports their idea that fluorine and hydroxyl are mutually replaceable. (*Amer. Jour. Sci.*, xliv. 114.)

A. Keungott has made a critical examination of analyses of tourmaline and comes to the conclusion that this mineral is an isomorphous mixture of two silicates having the general formulæ

$$3R_2O.SiO_2 + 5(R_2O_3.SiO_2) \text{ and } 2(3RO\ SiO_2) + R_2O_3.SiO_2$$

respectively. (*Neues. Jahrb.*, 1892, i. 3.)

A description by **Bruno Doss** of the meteorites of Misshof is interesting, for a new explanation which he gives of the cannon-like reports heard during meteoric falls. Basing his conclusion upon the results recently obtained by the instantaneous photography of projectiles in motion, he ascribes the phenomenon to the production of the air-wave in front of the moving meteorite, which at first proceeds with the same velocity as the stone, but

moves on in advance as soon as the velocity of the meteorite has become, by the effect of the resistance of the air, less than the normal velocity of sound. (*Neues Jahrb.*, 1892, i. 71.)

The artificial production of minerals.

C. Friedel has succeeded in obtaining crystals of the rare mineral percylite by bringing a solution of copper chloride into contact with lead hydrate by a process of slow diffusion by means of a cracked tube. (*Bull. Soc. Fr. Min.*, xv. 96.)

Accidental syntheses of pseudobrookite, hæmatite, and anhydrite, in the soda manufactory of Schönebeck, are described by **Bruno Doss**. The pseudobrookite is supposed to have resulted from the action of water-vapour upon ferric and titanic chlorides. This synthesis derives its interest from the support which it gives to the views held by A. Koch, the discoverer of the mineral, that the pseudobrookite of Aranyer Berg was a secondary sublimation product resulting from the effect of fumaroles upon the original rock. (*Zeits. Kryst.*, xx. 566.)

An accidental synthesis of melilite, in the factory of Ascania, in Nieuburg, is noted by **G. Bodländer**. Optically it was positive, and the author is inclined to attribute this to the high percentage of magnesium ; but F. Becke, in a note on the optical character of melilite as a rock-constituent, brings forward the theory, to account for the varying optical character, that rock-forming melilite is an isomorphous mixture of two end members, of which the one with negative double refraction is the Vesuvian humboldtilite, while the positive one is still unknown. This idea is in harmony with the extraordinary weak double refraction of rock-forming melilite as compared with humboldtilite. (*Neues. Jahrb.*, 1892 i., 53, and *Min. Mitth.*, xii. 444.)

Some new minerals.

Masrite, described by **H. Droop Richmond** and **Hussein Off**, is a variety of alum from Egypt, which contains from 1 to 4 per cent. of cobalt, an element not hitherto met with in that country. The mineral derives its chief interest, however, from the presence in it of what appears, from the author's experiments, to be a new element, "masrium," which comes prepared to conveniently fill one of the vacant spaces in the periodic system in the beryllium-calcium group. (*Jour. Chem. Soc.*, lxi. 491.)

Geikielite, optically examined and analysed by **A. Dick**, is a magnesium titanate, which was found by J. Baddeley at Rakwana, Ceylon. (*Nature*, xlvi. 620.)

Baddeleyite is another mineral found by J. Baddeley in the same locality. Chemical and crystallographic examination by

L. Fletcher showed it to consist of zirconia, and to have monosymmetric symmetry. This is of interest, since, in spite of the wide prevalence of the silicate zircon, no occurrence of the oxide of zirconium alone has been hitherto observed. (*Nature*, xlvi. 620.)

Josephinite is a new nickel-iron, found by **W. H. Melville** in magnetic pebbles in the placer gravel of a stream in Oregon. Beside the nickel-iron, the pebbles contain serpentine with bronzite (?), chromite, and pyrrhotite (troilite). The author gives evidence to prove the terrestrial origin of the mineral. It shows no Widmanstättan figures on etching and contains no phosphorus. (*Amer. Jour. Sci.*, xliii. 509.)

New apparatus and methods.

The use of oblique illumination as a means for distinguishing between uniaxal and biaxal mineral sections is pointed out by **J. L. C. Schroeder van der Kolk.** The rise or fall in Newton's scale of the interference colours is noted for slight rotations of the plate about two axes parallel to the shorter diagonals of the nicols. For uniaxal crystals, not cut parallel or at right angles to the axis, there is complete symmetry in the change of colours for rotations in either direction about one of these axes. (*Zeits. f. Wiss. Mikr.*, viii. 456.)

E. v. Fedorow describes a new "universal stage" for the optical examination of crystal plates, which allows of a rotation about two axes at right angles. The author makes use of the apparatus to determine what he names the "Hauptrichtung" in twin crystals. The "Hauptrichtung" is a second direction (besides the crystallographic twin-axis), along which the two halves of a twin extinguish uniformly. The author proposes the determination of this direction as a means for discriminating between species. Thus, in the felspars anorthite has the remarkable property that the "Hauptrichtung" coincides with one of the optic axes, whereas in labradorite the angle between these two directions is large. (*Min. Mitth.*, xii. 505; and *Neues. Jahrb.*, 1892, ii. 68.)

V. Goldschmidt describes a convenient piece of apparatus for centering and adjusting small crystals on the goniometer. (*Zeits. Kryst.*, xx. 344.)

Igneous rocks.

Sir Archibald Geikie's two anniversary addresses to the Geological Society for 1891-2 constitute important contributions to the history of volcanic action within the area of the British Isles. In the present address this history is carried forward from the end of the Silurian period to older Tertiary time, when the last British volcanoes became extinct.

In the concluding portion of the address the author emphasises some of the more general facts of larger import which this history may contribute to the investigation of the nature of volcanic action.

With regard to the distribution of volcanic action in the British Isles, a striking fact is the continued recurrence of eruptions in the western and their absence in the eastern tract. The persistence of volcanic activity over limited areas in which eruptions have broken out again and again after long periods of quiescence is also remarkable. The sites of volcanic vents, as a rule, do not appear to depend upon lines of faults, but they are always along low ground and valleys. As regards the possible connection between volcanic action and geological changes, one fact is certain, viz., that British volcanoes have been active on sinking rather than on rising areas. Two types of volcanic manifestation may be recognised : the ordinary type of volcanic vents, and a second type characterised by the formation of abundant fissures and the uprise of lavas in them forming dykes.

Concerning the changes taking place in the molten magmas, from which the volcanic materials proceed, the author remarks that in the Blackburn picrite there is a lower layer rich in heavy basic constituents, and an upper containing larger proportions of the lighter felspars : he suggests that similar effects may have taken place in the main mass of the magma itself. With the exception of the Snowdon region, the first eruptions of lava were always more basic than the final intrusions ; basalts and porphyrites were always followed by acid felsites and granophyres. In the molten magma, therefore, there appears to have been at first a separation of the more basic constituents. (*Proc. Geol. Soc.*, xlviii. 60.)

This subject of the differentiation of molten magmas constitutes the main interest of a valuable paper by **J. J. H. Teall** and **J. R. Dakyns** on the plutonic rocks of Garabal Hill and Meall Braec, in which they describe a complex of granular rocks of different ages, but evidently belonging to one geological epoch.

The rocks range from ultra-basic peridotites through diorites and tonalites to granites, and when two adjacent rocks differ in age, the more acid is invariably the younger. There is a striking resemblance between this order of succession of the rocks, and the order in which the minerals in them commenced to form. In both cases it is from basic and heavy to the most siliceous and light.

The authors consider that the area which they have studied represents a vast subterranean reservoir which has become differentiated during the process of consolidation into local magmas,

more and more acid; and that this separation was mainly due to the formation of the minerals in the above order of decreasing basicity. (*Quart. Jour. Geol. Soc.*, xlviii. 104.)

Lastly, the whole question of the nature of the differentiation of molten magmas receives exhaustive treatment at the hands of **J. P. Iddings** in a paper on the origin of Igneous Rocks.

The author brings forward a long series of petrographical, chemical, and geological data to show the consanguinity of the rocks forming a natural group, and their derivation from one common source; but he differs from Brögger and Teall in considering that the chemical variability of the rocks proves that the differentiation from the primary magma was not due to the separation of definite minerals, or even of such definite molecules as those designated by Rosenbusch as "Kerns," but rather to a chemical separation affecting the elementary oxides of the constituent elements.

In all the localities (chiefly Electric Peak and Sepulchre Mountain in the Yellowstone Park) studied by the author, he finds the order of succession of the rocks to be the same as that found by Judd for the lavas of the Lipari Islands, viz., from a rock of average composition to extremes of basic and highly acid rocks. He considers that this general law of sequence holds good for the volcanic rocks of all epochs. The analysis which he makes of the order of succession of the volcanic rocks of Great Britain, as given in Sir A. Geikie's address, in his opinion tends to confirm the above law, and not to support the idea of Geikie and Teall that the order is simply from basic to acid.

The causes of the differentiation of molten magmas must be looked for in theories regarding the nature of solutions, as *e.g.*, the principle of Soret that there will be a concentration of matter in the cooler parts of a solution, and the principle of Gouy and Chaperon, that when solutions become heavier by concentration the lower part will be more concentrated than the upper. (*Bull. Phil. Soc., Washington*, xii. 89.)

In connection with this subject it is interesting to note that **A. Irving**, from his field work on the Malvern crystallites, comes to the conclusion that the whole mass is of igneous origin, and in fact represents a segregation product of one original unerupted magma, the coarse pegmatitic rocks forming the siliceous residue after the heavier basic constituents had separated out. The intrusive dolerites, he considers, were portions of a deep magma which simply flowed into great fissures of the granite-diorite series. The diorite-gneiss was converted into amphibolite by differential movement prior to final consolidation. He regards

the schistosity of many of these rocks as resulting from mechanical forces, but thinks that the development of new minerals in this way was very limited. (*Geol. Mag.* [3], ix. 452.)

A. Harker discusses the genetic connection of the north of England lamprophyres with the Shap granite, and invokes the aid of a deep-seated reservoir of molten magma, separated into layers of varying density by the influence of gravity, to account for their chemical composition. The lamprophyres, according to the author, appear to be basic modifications of plutonic rocks in which, with a considerable diminution of silica, the amount of the alkalies shows little change, while the potash increases at the expense of the soda. To account for these facts the author advances the hypothesis that, as the plutonic magma cooled, crystals of orthoclase separated out in the upper layer and sank to the bottom, into the more basic portion, where they were at a later stage, on the release of pressure, partially redissolved. The presence of porphyritic quartz crystals in basic rocks is accounted for in a similar way. (*Geol. Mag.* [3], ix. 199 and 485.)

H. Foerstner, in a paper on a glassy basalt from the new volcanic island by Pantellaria, thrown up in the eruption of December, 1891, points out the remarkable uniformity in chemical composition of the basalt eruptions which have taken place since the Tertiary period in the volcanic region extending from the Lipari islands through Sicily to Tunis. (*Min. Mitth.*, xii. 510.)

The general uniformity in type of the igneous rocks of Australia and those of Europe and America, is illustrated by a contribution by **J. Milne Curran** to the microscopic structure of a large series of rocks from Eastern Australia. An interesting fact is the wide distribution of leucite rocks in New South Wales. (*Jour. Proc. Roy. Soc.*, N.S.W., xxv. 179.)

Grenville A. J. Cole and **G. W. Butler** describe the structure and probable mode of origin of the lithophyses in the Roche Rosse Obsidian. They distinguish two modes of growth, the one divergent outwards from the margins of steam vesicles, the other convergent inwards towards the centre until, in some cases, the fibres meet, and thus form a solid spherulite. The authors consider that the lithophysal structure of this lava stream was produced during the cooling of the mass, and not by later amygdaloidal filling up of the vesicles. (*Quart. Jour. Geol. Soc.*, xlviii. 438.)

H. J. Johnstone-Lavis offers a different explanation of the mode of formation of these lithophyses. Whereas the preceding authors regard the universal association of cavities and spherulitic

growth as due to the formation of steam vesicles, he holds that this association may be attributed (1) to the liberation of steam during crystallisation, and (2) to the fact that the crystalline aggregates (spherulites), when formed, would afford surfaces favourable to the disengagement of gas from the surrounding glass. (*Geol. Mag.* [3], ix. 488.)

A. Bergeat gives a contribution to our knowledge of the massive rocks of Cyprus. (*Min. Mitth.*, xii. 263.)

T. H. Holland records the occurrence of Riebeckite in Southern Sikkim. (*Records Geol. Survey, India*, xxv. 159.)

T. G. Bonney describes the Euphotide or Saussurite-smaragdite gabbro of the Saasthal. The erratics so abundant in this valley are derived from a spur of the Allaleinhorn. Amongst these erratics the author notes five tolerably-distinct varieties of gabbro. The spur itself consists for the most part of a hornblendic variety, showing signs of foliation, and the smaragdite, so plentiful in the erratics, so far as he saw, occurs only locally. Microscopic examination showed that most of the constituents of these rocks were of secondary origin : the saussurite was evidently an alteration product of a lime-felspar, while the smaragdite was derived from diallage. The author failed to find signs of dynamo-metamorphism to account generally for the foliation, but refers this structure, as a rule, to fluxional movements, as in the case of certain of the Lizard gabbros. (*Phil. Mag.* [5], xxxiii. 237.)

Crystalline schists and metamorphic rocks.

E. Hill and **T. G. Bonney**, in a paper on the hornblende schists, gneisses, and other crystalline rocks of Sark, point out the remarkable resemblance which many of these rocks bear to those of the Lizard. The basement gneiss is similar in structure to the more granitoid bands in the granulitic group of the Lizard : it is probably of igneous origin and intrusive into, instead of older than, the hornblende schists and banded gneisses which appear to succeed it. The hornblende schists correspond very closely with those of the Lizard. The banded gneisses, of which two types are distinguished, one moderately coarse in texture and the other finer-grained and less micaceous, resemble in many respects the granulitic group of the Lizard. A remarkable group consists of basic hornblendic rocks which have been broken up and in parts actually melted down by the intrusion of acid felspathic aplites. The result in places has been the production of a banded biotite gneiss.

The authors assign an igneous origin to all these rocks, and attribute the banding to fluxional movements anterior to final consolidation. (*Quart. Jour. Geol. Soc.*, xlviii. 122.)

The use of the microscope in helping to elucidate the problem of the origin of the crystalline schists forms the main theme of the Rede lecture for 1892, delivered by Prof. Bonney. The result of the latest researches has been to demonstrate that true crystalline schists are very old, all probably older than any rock in which traces of life are found. "The environment necessary for changing an ordinary sediment into a crystalline schist existed generally only in the earliest ages, and but very rarely and locally, if ever, since Palæozoic time began." Since that time the zone for marked mineralogical changes has been continually sinking. "The subterranean laboratory still exists, but the way to it was virtually closed at a comparatively early period in the earth's history." (*Nature*, xlvi. 180.)

Lastly the same author, in a paper on the so-called gneiss of Carboniferous age at Guttanen, emphasises his contention that although fragmental rocks, such as this, may by the effects of dynamo-metamorphism be made to imitate true crystalline schists, yet the fraud can always be detected by the practised eye. (*Quart. Jour. Geol. Soc.*, xlviii. 390.)

In an elaborate memoir on the geology of the Alps between the Reuss and Rhein **A. Heim** refers to Prof. Bonney's paper on the Crystalline schists and their relations to the mesozoic formations of the Lepontine Alps. (*Quart. Jour. Geol. Soc.*, xlvi. 187.) He agrees with him in considering that it is possible to keep the old crystalline schists and the metamorphosed sediments distinct; but maintains, contrary to Prof. Bonney, the Jurassic age of the Andermatt marble and of all the Val Piora schists. The author considers that the Bündner schists form a single Jurassic system, and that they represent a series of clay, calc, and quartz sediments which have become crystalline by dislocation-metamorphism connected with the post-eocene Alpine folding. (*Beit. z. Geol. Karte d. Schweiz. Blatt.*, xiv.)

A method which may be of great service in helping to ascertain the origin of crystalline schists and metamorphic rocks is described by **O. A. Derby** in a paper on the separation and study of the heavy accessories of rocks. For this separation he advocates the use of a batêa or Brazilian miner's pan of copper instead of the porcelain dishes of the laboratory, and points out what light may be thrown upon the origin of rocks by a determination of these heavier and almost indestructible accessories. Thus the opinion now gaining ground, that many of the Brazilian gneissic rocks and felspathic mica schists are dynamo-metamorphosed eruptive rocks, is supported by the presence in them of zircon and monazite in about the same abundance and with the

same sharpness of outline as in the typical granites. (*Proc. Rochester. Acad. Sci.*, i. 190.)

W. Salomon continues his work on the contact phenomena of the rocks of the Tyrol. The eruptive masses of Klausen, Predazzo, and Monzoni have produced interesting contact metamorphism in the surrounding sediments, but no account has hitherto appeared of similar effects due to the granite mass of Cima d'Asta. The author describes typical contact rocks at eight different points round this granite mass. They belong to the quartz and gneiss phyllite groups, and are all characterised by the occurrence of contact minerals such as andalusite and cordierite.

The author has also made a series of new observations on the Adamello range. The tonalite gneiss, which Stache had made use of in order to fix the age of the tonalite, is, in the author's opinion, only a dynamo-metamorphic modification of the tonalite itself. He finds that this gneiss-like tonalite is bounded by lines along which powerful movements of the rock occurred, and in the neighbourhood of which the rock mass naturally underwent considerable pressure. (*Giorn. d. Min.*, iii. 97.)

Sedimentary rocks.

H. B. Woodward gives an explanation of the peculiar appearance and mode of formation of the well-known landscape marble or Cotham stone. The rock itself occupies an intermediate position between dark argillaceous sediments and the almost pure calcareous white lias. According to the author it marks a period when occasional films of dark mud were deposited with the calcareous sediment, and the arborescent markings are due to the disarrangement of these dark films during the consolidation of the stone owing to the shrinking of its upper portion. (*Geol. Mag.* [3], ix. 110.)

W. M. Hutchings has transferred his attention from the sedimentary roofing slates of North Wales and Cornwall to the volcanic ash-slates of the Lake district. These slates for the most part consist of lapilli of the normal andesitic rocks of the district, fragments of felspar, calcite, etc., in a very fine-grained base made up of chlorite, sericitic mica, and garnets with free silica. The original andesitic or other volcanic dust therefore decomposed in such a way that the ferro-magnesian constituents gave rise to chlorite and garnet, while the felspar was altered to mica.

An interesting point is the mode of occurrence of titanic acid. The rutile needles, which the author has found to be so characteristic a feature of the sedimentary clays and slates, are wholly

absent from these volcanic ash-slates. In these the titanic acid occurs in small crystals of secondary sphene, but mainly in the form of anatase. (*Geol. Mag.* [3], ix. 154, 218.)

STRATIGRAPHICAL GEOLOGY.

BY HORACE B. WOODWARD, F.G.S.

IN this division some of the principal advances have been made by the recognition of certain zones, or palæontological horizons, in areas widely separated, as, for example, the occurrence of the Olenellus zone in Scotland, of the Clymenia stage in New York, and of strata that may be grouped with the Lias, in California. The general recognition of Permian beds in Devonshire is of interest. The interpretation of over-thrusts, whereby older strata are thrust across newer formations, has served to elucidate the structure of portions of the country near Marseilles, and also the gold-bearing regions of the Transvaal. The physical and palæontological history of the Pleistocene deposits of Sussex has also been worked out from the records of the strata; and evidence has there been obtained of an inter-glacial episode.

I.—PALÆOZOIC OR PRIMARY.

B. N. Peach and **J. Horne** have published full particulars of the discovery of the Olenellus zone between Loch an Nid and Achneigie, in Dundonnell Forest, western Ross-shire. The new species of Trilobite from this locality is named Olenellus Lapworthi, and fragments of it were found in dark blue shales that occur near the top of the "Fucoid Beds," and towards the base of the overlying "Serpulite Grit." These rocks form part of a belt of fossiliferous strata, that extends from Loch Eriboll to Strome Ferry. Of special interest too is the occurrence of Serpulites Maccullochi (Salterella) and Hyolithes, in brown dolomitic bands associated with the Olenellus shales. Underlying the "Fucoid Beds" is a band of "Pipe rock" with vertical burrows of Annelides, and this division rests on quartzites which form the sandy base of the Cambrian system. Unconformably beneath these strata lies the Torridon sandstone, which is thus shown to be pre-Cambrian. (*Quart. Jour. Geol. Soc.*, xlviii. 227.)

Sir Archibald Geikie has prepared a new Geological Map of

Scotland (on a scale of 10 miles to an inch), accompanied by explanatory notes. The newest work of the Geological Survey is represented on the map, and this relates principally to the older rocks. The oldest rock is marked as Lewisian Gneiss, and it is stated to be mainly a mass of eruptive rocks, which have undergone great mechanical deformation, and have thus acquired a gneissose or schistose structure; but, in places, indications of sedimentary strata, in the form of graphite-schist, limestone, and granulitic mica-schist, seem to be recognisable as parts of the so-called gneiss. The eastern or younger schists, grouped as Dalradian, cannot as yet be placed in a definite position in the stratigraphical series, for although traces of Annelides have been detected in some of the quartzites, no distinctive fossil evidence has been obtained. The rocks are regarded as pre-Cambrian. A general account is given of the succeeding strata, from the Torridon sandstone to the recent accumulations. (Edinburgh: Bartholomew and Co.)

J. F. N. Delgado notes the existence of fossils in chiastolite slates (schistes maclifères) of Upper Silurian age, near Recarei, in the neighbourhood of Vallongo. He has observed traces of a Graptolite in chiastolite slate, and from associated rocks he has obtained a specimen of Illænus lusitanicus and the internal cast of a Redonia. He records also the occurrence of Discophyllum in a bed of quartzite with Bilobites, at the base of the Lower Silurian of Busaco; and further announces the discovery of an Alga in a diabasic tuff of Cambrian age in Alto Alemtejo. This last rock is described by **A. Bensaude.** (*Comm. dos Trabalhos Geologicos, Lisbonne,* ii.)

Charles Barrois has published a Memoir on the Distribution of Graptolites in France. His researches were undertaken with the view of testing whether the zones, that have been shown to extend from Scotland to Scandinavia, were likewise present in France. Graptolites occur in Languedoc, the Pyrenees, the Corbières, Ardennes, Normandy, and Brittany; but with the exception of those found in Languedoc and Normandy, they are as a rule poorly preserved and difficult of determination. They are found in greatest abundance in carbonaceous clay-slates, but they occur also in limestones and in sandy beds, showing that they were dispersed irrespective of sedimentary conditions. The results obtained by M. Barrois coincide generally with those of Prof. Lapworth in Britain, although less abundant material has been gathered in France, especially among the Ordovician rocks; and thus several forms of Graptolites, elsewhere found, are at present unknown from the districts mentioned. The facts

obtained in both Ordovician and Silurian rocks of France show, however, the same sequence in the forms of life that characterize zones in other parts of Europe, and even in America. (*Ann. Soc. Géol. du Nord*, xx. 75.)

J. E. Marr, in an article on Life-Zones in Lower Palæozoic Rocks, points out the value of Graptolites in marking stages in the life-history of the older rocks, and in affording means for correlating strata in different areas all over the world. He points out the importance of variations in species that, by experience in the field, are found to characterise successive periods of time. These varieties that succeed one another in time, are different from those that co-exist with the normal form; and he proposes to distinguish them by the term "exallagous" forms, for they are all important to the stratigrapher. In a supplementary note he mentions that the term "mutations" had previously been used to denote these variations of species in time. (*Natural Science* (1892), 124, 240.)

J. E. Marr subdivides the Coniston Limestone series of the English Lake district and adjoining areas, as follows:—

Ashgill Group ...	Ashgill shales	50 feet.
	Staurocephalus-limestone ...	5 "
Sleddale Group ...	Applethwaite beds	100 "
	Conglomerate	10 "
	Stile End beds	50 "
Roman Fell Group	Corona-beds	100 "

The author notes the characters of the strata and the principal fossils. The Corona-beds are characterised by the Brachiopod, Trematis corona, and the Staurocephalus-limestone by the Trilobite, Staurocephalus globiceps. The beds belong to the Bala or Caradoc series: but some of the palæontological horizons enable comparisons to be made further afield. Thus the Roman Fell beds are compared with the Beyrichia-limestone of Scandinavia, and the Trenton-limestone of North America; while the equivalents of the Staurocephalus-limestone occur in many parts of Britain as well as in Scandinavia. (*Geol. Mag.* [3], ix. 97.)

J. E. Marr also gives a detailed account of the zones in the Wenlock and Ludlow strata of the Lake district. (*Geol. Mag.* [3], ix. 534.)

J. Milne Curran describes the Silurian, Devonian, and Upper Tertiary strata, as well as eruptive rocks, of Bathurst, in New South Wales. The Silurian rocks comprise slates and limestones, that have yielded Petraia, Stromatopora, Favosites, and Phillipsastræa. Resting unconformably upon these rocks, are sandstones

and grits of Devonian age; they have yielded Spirifer disjunctus and Rhynchonella pleurodon. The newer deposits are all of Tertiary (Pliocene) and post-Tertiary age: and they are entirely alluvial. (*Proc. Linnean Soc., N. S. Wales*, vi. 173.)

John M. Clarke announces the discovery of Clymenia in the Upper Devonian rocks of western New York. The specimens were obtained in shales belonging to the Naples beds, and it is suggested that the fauna of these beds embraces representatives of the whole series of the European Upper Devonian faunas, from the base of the Goniatite-limestone to the base of the Culm-strata. (*Amer. Jour. Sci.*, xliii. 57.)

C. S. Prosser gives an account of the Devonian system of eastern Pennsylvania. He describes the Lower Devonian (including Cauda-galli grit and Upper Helderberg or Corniferous limestone); the Middle Devonian (Marcellus shales and Hamilton stage); and the Upper Devonian (Tully limestone, Genessee shales, Portage, Chemung, and Catskill beds). Lists of fossils are given, and important data are thus furnished for correlating the strata with the Devonian series of central New York. (*Amer. Jour. Sci.*, xliv. 210.)

J. Gosselet, in a note on the relations between the Devonian and Carboniferous strata of Visé, N.E. of Liege, remarks that the Devonian limestone, belonging to the Frasnian stage, is overlain directly by the upper part of the Carboniferous limestone. The junction is so close that in the same block, part is Carboniferous and part Devonian; while the author states that between the two limestones there is an immense hiatus, corresponding to the Famennian, Tournaisian, Wauhortian, and the base of the Visean; beds which elsewhere in the neighbourhood have a thickness of about 500 metres. (*Comptes Rendus*, cxiv. 1242.)

E. J. Dunn announces the discovery of a Glacial conglomerate (probably of Carboniferous age) near Sandhurst, in Victoria. (*Rep. Department of Mines, Melbourne*, 1892; see also *Nature*, Nov. 17 and Dec. 1.)

W. Boyd Dawkins relates facts concerning the further discovery of coal at Dover. Coal-measures were reached at a depth of 1,113 feet from the surface, and had been proved to a further depth of nearly 750 feet. Nine seams of coal were found, and these had a united thickness of 17 feet 8 inches. The inclination of the beds was at the gentle angle of 2°. (*Trans. Manchester Geol. Soc.*, xxi. 456.) **E. Lorieux** gives the most detailed account at present published of all the strata passed through in the Dover boring, from a report of Mr. Brady, engineer. (*Ann. des Mines* [9], ii. 227.)

II.—MESOZOIC OR SECONDARY.

T. G. Bonney describes the rock-fragments found in the Permian breccia of Leicestershire. Among these many of the old Charnwood rocks are represented, as well as various Carboniferous rocks. The occurrence of stones derived from the Coal-measures supports the view of the unconformity between these strata and those of Permian age. With regard to certain striated fragments, though ice-transport was probable, he doubted if these were evidence of ice-action. (*Midland Nat.*, xv. 25, 49.)

Maria M. Ogilvie discusses the sequence and fossils of the Upper Triassic strata of the neighbourhood of St. Cassian, in the Tyrol. These strata comprise, in ascending order, the Wengen beds, the Cassian beds, and the Schlern Dolomite. A detailed study of the rocks and fossils shows that further subdivision of the Wengen and Cassian beds can be made, each subdivision being distinguished by lithological and palæontological characters peculiar to itself. (*Geol. Mag.* [3], ix. 145.)

A. Leppla gives an account of the Permian and Triassic rocks, Zechstein and Buntsandstein, in Waldeck-Kassel. (*Jahrb. K. Preuss. Geol. Landes. und Bergakad.*, xi. 40.)

M. Bertrand shows that "outliers" of Muschelkalk and Variegated Marls occur on various newer Secondary strata, in the Vieux Beausset, at Rouve, and at Fontanieu, in the country between Marseilles and Toulon. Some of these outliers were at one time thought to be islands or bosses of Triassic strata, protruding through the newer rocks; they have now been proved to be remnants of the strata, that had been shifted across the newer rocks by means of thrust-faults. (*Bull. Soc. Géol. France* [3], xix. 1062.)

J. G. Goodchild has discussed the classification of the New Red series of the Vale of Eden and the borders of the Lake district. These rocks rest with marked unconformity on the Coal-measures and older strata, and they are overlain by the Lias (and possibly Rhætic beds) in the neighbourhood of Carlisle. They have been divided into Permian and Trias, although the plane of separation has been taken at different horizons by those who have made a study of the rocks. In reality they are a continuous series of deposits, formed, from base to summit, under one set of conditions. The lower portion of the series includes beds of Magnesian Limestone and Plant-beds (that may be correlated with the Magnesian Limestone of Durham and the Zechstein of Germany); and still older beds (of Penrith Sandstone) that contain footprints of

Saurians and Labyrinthodonts. The upper portions of the series comprise, in ascending order, gypsiferous marls, which Mr. Goodchild proposes to term Bunter Marls, and these are overlain by the St. Bees Sandstone, which in his opinion passes up into the Kirklinton Sandstone. Both sandstones are grouped by him as Bunter Sandstone, and this division is overlain by the Keuper Marls. He sees evidence of local discordance between the Bunter Marls and the older portion of the New Red series, to which he would apply the term Dyas. He believes that the so-called Permian Rocks of Staffordshire and adjacent areas belong to an older set of beds than the Dyas just described—older, in fact, than the Magnesian Limestone series. These Permian rocks are intimately connected with the Carboniferous rocks, and may therefore partially fill up the gap between the Coal-measures and New Red rocks elsewhere. He would restrict the term Permian to this older group, and thus separate Permian from Dyas, placing the latter (with the Magnesian Limestone) in the Mesozoic division, and leaving the restricted Permian with the Palæozoic. (*Rep. Brit. Assoc.*, 1892, *in the press*; and *Trans. Cumberland and Westmoreland Assoc.*, No. 17.)

T. Tate records some recent borings in the Durham Salt-district. The evidence shows, in places beneath the Drift deposits, the following sequence in the New Red rocks :—

Upper Keuper	Red Marls	495 feet.
	Red Sandstones and Marls	869 "
	Saliferous Marls	429 "
Permian ...	Magnesian Limestone (with marls, anhydrite, and gypsum)	299 "

The beds are grouped as above by the author. On Lackenby foreshore a boring 1,806 feet deep, proved a bed of rock-salt 119 feet thick. (*Quart. Jour. Geol. Soc.*, xlviii. 488.)

E. Hull compares the New Red rocks of South Devon with those of the Midland and Western counties, and would classify them as follows (*Quart. Jour. Geol. Soc.*, xlviii. 60) :—

Trias ...	Keuper	Red Marls and Sandstone, with calcareous Breccia at base : east of Sidmouth.
	Bunter	Sandstone : of Sidmouth.
		Pebbly Sandstone and conglomerate : of Budleigh Salterton.
		Lower Red Marls and Sandstone : of Exmouth.
Permian		Breccias : of Teignmouth, etc.

A. Irving also regards the main portion of the red sandstones of Sidmouth as Upper Bunter; and although they have yielded

Amphibian and Reptilian remains that have been regarded as of Keuper age, he points to the occurrence of Amphibian remains in the Bunter beds of Germany, to show that their presence is no precise indication of horizon. He regards the Lower red marls and sandstone of Exmouth as the top of the Permian beds; and the underlying breccias to belong also to that formation. In support of this view he points to the contemporaneous volcanic rocks as strong evidence of the Permian age of the breccias; for such volcanic rocks are met with, not only in Ayrshire, but also in Germany in the same set of strata, while they are unknown in the Trias of those localities. (*Quart. Jour. Geol. Soc.*, xlviii. 68.)

W. A. E. Ussher admits the probable Permian age of the New Red breccias of Devonshire. (*Geol. Mag.* [3], ix. 247.)

The Sedgwick Prize Essay, by the late **Thomas Roberts**, on the Jurassic Rocks of Cambridge, has just been published. It contains accounts of the Oxford Clay, Corallian Beds, and Kimeridge Clay, with full particulars of their organic remains. The Coral Rag and Coralline Oolite of Upware are regarded as equivalent to the Ampthill Clay; the Lower Calcareous Grit being represented by the Elsworth and St. Ives Rocks. The Upper Jurassic rocks of Cambridgeshire and Huntingdonshire are compared with those in other parts of England, and with equivalent beds in the Paris Basin, the Jura, and in Hanover.

H. B. Woodward gives a general account of Geological Zones, with especial reference to those that may be recognised in British Jurassic rocks. (*Proc. Geol. Assoc.*, xii. 295.)

A deep boring at Mickleton Manor, Gloucestershire, has been completed by Messrs. Le Grand and Sutcliff. After passing through about 280 feet of Middle Lias (marlstones, sands and shales), no less than 961 feet of Lower Lias limestones and shales were proved, then about 74 feet of Rhætic Beds, and the boring was continued 27 feet into the Keuper Marls, having reached the depth of 1,342 feet. The Lower Lias proved to be thicker than it is known to be elsewhere in Britain.

C. F. Parona, in an account of the Lower Lias of Saltrio in Lombardy, enumerates, among others, many species familiar to this country, such as Pleuromya Galathea, Cardinia hybrida, Lima gigantea, etc. (*Atti. della Soc. Italiana di Sc. Nat.*, xxxiii. 69.)

J. S. Diller and **Alpheus Hyatt** have published accounts of the Geology of the Taylorville Region of California, and they recognise a larger number of Jurassic formations than have been noticed elsewhere in the United States. The area where these are developed has been named Mount Jura, and this lies between

Taylorville and Genessee. Beds, referred with some doubt to the Upper Lias, are recorded. They contain species of Goniomya, Gryphæa, Lima, Modiola, Pecten, Pinna, Pleuromya, Ostrea, Trigonia, and also Glyphea, many of which are closely related to European Upper Lias forms, while others are nearer to Lower Lias forms. No Ammonites have at present been found in these beds, which are termed the Hardgrave Sandstone. In strata, grouped with the Inferior Oolite, there are species allied to Ammonites Gervillei and A. toarcensis. In higher strata, assigned to the Callovian, there are few fossils; but a still newer series of sandy rocks and tuffs has yielded species of Chemnitzia, Gryphæa, Trigonia, and Stylina, that have Corallian affinities. The beds are much folded and overthrust in places; but it is stated that in some areas the Inferior Oolite rests unconformably on Triassic limestone. The total thickness of the Jurassic strata is estimated to be 1,980 feet. (*Bull. Soc. Geol. America*, iii. 369 and 395.)

W. Kilian records the discovery of Upper Jurassic beds in the Alpine regions of Grand-Galibier (Hautes-Alpes). The beds belong to the Tithonic group, and they rest on Dogger (?) and Lias—all the strata being bent into an inverted synclinal. The Tithonic beds yield Aptychus Beyrichi, A. punctatus, Belemnites latus, B. Conradi, Phyllocrinus, etc. A breccia at the base is said to contain debris from the Trias and Lias. (*Bull. Soc. Géol. Francc* [3], xx. 21.)

Paul Choffat briefly notes the occurrence of Rhynchonella correcta and some other fossils in the limestone of Gibraltar. He sees no reason to doubt that the rock is of Liassic age. (*Bull. Soc. Géol. France* [3], xx. p. ix.)

A. de Grossouvre remarks that at the base of the ferruginous oolite of Bayeux, in Normandy, there occur phosphatic nodules that enclose more or less rolled Ammonites, belonging to a lower stage of the Inferior Oolite. The species include Ammonites Sauzei, A. Brocchii, A. Gervillei, A. Brongniarti, etc. (*Bull. Soc. Géol. France* [3], xx. p. xix.)

O. Behrendsen enumerates, in more detail, the fossils of different Jurassic, Cretaceous, and Tertiary rocks of the Argentine Cordilleras (noticed in the "Year-Book" for 1891, p. 290), and figures many new species. (*Zeitsch. der Deutsch. Geol. Gesell.*, xliv. 1.)

A. Pavlow and **G. W. Lamplugh** describe the Jurassic and Neocomian strata of Lincolnshire and of Speeton in Yorkshire, and compare them with equivalent beds in Russia and other tracts of country. Their researches lead them to conclude that the Spilsby Sandstone, and part of the Claxby ironstone of Lincolnshire, together with the Speeton Beds (above the

Kimeridge Clay) up to the top of the zone of Belemnites lateralis, should be grouped with the Portlandian and Purbeckian beds (Tithonic); while the higher beds, including the Tealby Clay and Limestone, belong to the Wealden beds and Lower Greensand. It is considered desirable to group the Portland and Purbeck beds together; and on general grounds of convenience to place them both in the Jurassic system. The fossils of the Speeton beds and their equivalents are very fully described by M. Pavlow; and they are illustrated by eleven plates. (*Bull. Soc. Imp. des Naturalistes, Moscow*, Nos. 3 and 4 for 1891, 1892.)

E. Rigaux gives a particular account of the strata of the Bas Boulonnais. Silurian rocks have been proved by borings, and Devonian, Carboniferous, Jurassic, and Cretaceous strata appear at the surface. The Cretaceous rocks rest indifferently on the several Jurassic stages, and on the older rocks. Full lists of fossils are given. (*Mém. Soc. Académique, Boulogne*, xiv.)

W. F. Hume gives results of his observations on the Cretaceous rocks of south-west Russia. The Upper Cretaceous strata (exclusive of Cenomanian) attain a thickness of 1,830 feet at Kharkoff, but this diminishes both eastwards and westwards. The beds consist of white chalk and chalk marl, the former usually (but not always) overlying rock of the latter type. The lithological variations appear to have no effect on the character of the fossils. Tertiary strata rest unconformably on the Cretaceous rocks, which are bent into folds. Underlying these Cretaceous rocks are Cenomanian beds, which lithologically are mainly greensand, and are about 100 feet thick. (*Geol. Mag.* [3], ix. 385.)

W. Tzébrikow points out that between the Jurassic (Tithonic) beds of the Crimea and the Lower Cretaceous strata (of Mediterranean type) there is an insensible gradation. (*Bull. Soc. Imp. des Naturalistes, Moscow* [N. S.], vi. 86.)

A. Toucas tabulates the zones in the Cretaceous strata of Beausset. (*Bull. Soc. Géol. de France* [3], xix. 1,042.)

Ralph S. Tarr expresses his opinion that Cretaceous rocks formerly covered the Palæozoic region of Texas, and that some of the present streams have cut their way through these rocks, and have adjusted themselves to channels of ancient watercourses that were cut in the old rocks in pre-Cretaceous times. (*Amer. Geol*, March, 1892.)

III.—TERTIARY.

E. Delvaux describes a bed of sands below the Ypresian clay, that represents, in Belgium, the Oldhaven beds of the London Basin. (*Mem. Soc. Géol. Belgique*, xix. 83.)

M. Peron gives an account of the Middle and Upper Tertiary strata of Algeria. (*Bull. Soc. Géol. de France* [3], xix. 922.)

Louis Rollier describes the Tertiary strata of the Jura Bernois. (*Eclog. Geol. Helvet.*, iii. 43.)

IV.—QUATERNARY.

J. Prestwich details his observations on the Raised Beaches, and "Head" or Rubble-drift, of the South of England; and discusses their relation to the Valley Drifts and to the Glacial Period. He is of opinion that the Raised Beaches of the south and south-west of England were contemporaneous with the newer river-drifts of the Thames and Somme valleys; that an uplift not exceeding 120 feet followed the formation of these beaches; and then occurred the period of the Coast Caves and their fauna, and of certain Raised Dunes of Blown Sand. He further argues in favour of a late post-Glacial submergence, evidence of which, perhaps to an extent of 1,000 feet, is recognised in the remarkable accumulations of angular gravel or "Rubble-drift." Re-elevation followed after a short interval, and during the emergence there was formed the main portion of this Rubble-drift, which includes the accumulations known as "head," as well as the "Coombe Rock" of Sussex, etc. Some of the fissures filled with ossiferous drift were formed during this period of elevation. Following this final upheaval are the Alluvium of our rivers, and other deposits grouped as Recent. The author concludes that Glacial times came, geologically speaking, to within a measurable distance of our own times, and that the transition was short and almost abrupt. (*Quart. Jour. Geol. Soc.*, xlviii. 263.)

Clement Reid has described the succession of the Pleistocene deposits of the Sussex coast. Great boulders occur at the base of the series, some of them squeezed into the underlying Eocene strata. Among these are blocks, not only of greenstone and granite, but also of Eocene and Cretaceous rocks from the Isle of Wight, probably brought by shore ice; and the discovery was announced of a mass of Bognor Rock showing a well-marked striated surface, also probably the work of shore ice. The overlying sands and clays were shown to yield a temperate fauna and flora, while higher still in the series, the Coombe Rock bore evidence of a return of glacial conditions. The facts thus gave proof of an interglacial episode, and the author compared the sequence of events with that indicated by the Thames Valley deposits. He thought the low-lying marine glacial deposit of Sussex was the natural equivalent in time, though not in method

of formation, of the chalky Boulder Clay. The overlying marine and estuarine beds, with Corbicula fluminalis and remains of elephant and rhinoceros, compare with the fossiliferous loams of Ilford and other parts of the Thames Valley. The Coombe Rock is probably equivalent to certain wide-spread sheets of gravel in the Thames Valley, which Mr. Reid regards as frozen-soil gravels, laid down on plains sloping gently towards the river. (*Quart. Jour. Geol. Soc.*, xlviii. 344.)

H. Hicks records the discovery of portions of a large tusk, the lower jaw, and other remains of the mammoth (Elephas primigenius), together with other fossils, in the Pleistocene deposits, in Endsleigh Street, near Euston Station, London. The Mammoth remains were entombed in a dark clayey loam, that overlay the London Clay; and in the same loam a number of plant-remains (mostly seeds) were found, and identified by Mr. Clement Reid. These plants belong to species that are usually found in marshy places or ponds; they include no typically Arctic species, but such as extend from the Arctic Circle to the south of Europe. Overlying the loam were deposits of gravel and sand; then yellowish-brown clay with much "race" (concretions of carbonate of lime), and on top the usual "made soil" that occurs over the London area. The author compared the brown clay containing "race" with a similar clay that underlies the Boulder Clay at Finchley; and he comes to the conclusion that the Mammoth and other animals existed in the area prior to the glaciation indicated by the Boulder Clay. (*Quart. Jour. Geol. Soc.*, xlviii. 453.)

Sir H. H. Howorth cites a number of statements, which in his opinion prove that the beds in this country yielding remains of the Mammoth are older than the Glacial Drift. *Geol. Mag.* [3], ix. 396.)

A. Briart gives a particular account of the Hesbayan loams, and a general account of Quaternary times in Belgium. He divides the Hesbayan loams (limon hesbayen, of Dumont) into two distinct deposits: those of the higher plateaux and those of the plains. He considers that the two deposits follow on, respectively, the two principal epochs of glaciation, and that they were fresh-water lacustrine deposits. The Mammoth and the fauna associated with it, belong to an interglacial period between the two principal epochs of glaciation. (*Ann. Soc. Géol. Belgique*, xix. 15.)

H. Munthe has given a useful summary of what is known respecting the Quaternary strata of the Baltic shores and their fossils. (*Bihang till K. Svenska. Vet. Akad. Handlingar*, xviii.)

A. G. Nathorst summarises the knowledge respecting the fossil plants found in Glacial deposits in different countries, and indicates their value in fixing horizons. (*Ibid.*, xvii.)

R. D. Salisbury contributes a preliminary paper on the Drift or Pleistocene Formations of New Jersey. He remarks that the total area of the North American ice-sheet, at the time of its maximum expansion, has been estimated to be something like 4,000,000 square miles, and about thirteen times as large as the estimated area of the snow-field of Greenland at the present day. The ice-sheet had an earlier existence in Canada than in the United States; it invaded the northern, but not the southern, portion of New Jersey. The northern part of New Jersey is covered by a mantle of clay, sand, gravel, and boulders; sometimes in confused accumulations, at others in regular layers. This drift attains a thickness of 200 feet or more; and the general movement of the ice, as shown by striæ, was to the S.S.E. The larger part of the drift was transported beneath the ice and in its basal portions; part became lodged beneath the ice during its movement, and part was carried forward towards its edge and there deposited. Certain ridge-like belts, where the drift is thicker than elsewhere, are believed to mark the position in which the edge of the ice-sheet was constant for considerable periods. The action of ice was accompanied by that of water, which flowed from the margin of the ice-sheet. (*Ann. Report State Geologist, New Jersey*, 1892.)

F. J. H. Merrill contributes notes on the Post-Glacial Champlain Deposits of the Hudson River Valley. These deposits comprise estuarine beds of stratified clay and fine sand, that were laid down in still water; and cross-bedded delta deposits of coarser material. They fringe the river-shores in terraces between New York and Albany, and extend westwards to Schenectady, where they attain an altitude of 340 feet. At Manhattan Island the elevation is at most 75 feet. The evidence quoted, leads to the conclusion that after the retreat of the continental glacier, there was a depression, amounting to about 340 feet in the vicinity of Albany, and to about 80 feet at New York. Next occurred a gradual elevation, amounting to 180 feet or more at New York, and to perhaps 400 feet at Albany. During this elevation extensive erosion of the estuarine deposits took place, and subsequently there followed a depression which has amounted to at least 100 feet at New York, and which is apparently continuing at the present day. **H. Ries** supplements these observations with an account of the brick-clays, and of the manufacture of bricks. (*Rep. State Geologist, Albany, U.S.A.*, 1892.)

V.—MISCELLANEOUS.

W. Gibson has given a particular account of the Gold-bearing and associated rocks of the Southern Transvaal. He finds that the gold-bearing conglomerates, together with the quartzites and shales of the Witwatersrandt, form one definite geological series; but it has proved unfossiliferous, and neither its base nor its summit could be ascertained. The series is newer than the schists, granites, and gneisses that underlie it, and much older than the coal-bearing strata that rest unconformably upon it. Evidence is brought forward to show that the rocks in question have been subjected to much overfolding and overthrusting, and that these movements have been accompanied by much metamorphism. After the cessation of these earth-movements, there was a period of volcanic activity, basic dykes were injected, and much of the country was flooded with lava. The author's observations tend to show that the gold-bearing rocks may occur over larger areas than those within which they have at present been found. (*Quart. Jour. Geol. Soc.*, xlviii. 404.)

A. Issel has published three volumes entitled "Liguria Geologica e Prehistorica" (Genoa, 1892). It gives an account of the geology of the Mediterranean shores from Cannes and Nice to Genoa and Pisa, and is accompanied by geological and other maps.

PALÆONTOLOGY (VERTEBRATE).

By R. LYDEKKER, F.G.S.

I.—GENERAL.

K. G. Maska describes the fauna of a cavern in Moravia with human bones in association with those of other mammals. (*Jahrb. Geol. Reichanstalt*, xli. 415, pl. vii.)

M. Kriz has an article on the fauna of the Moravian caverns with lists of species. (*Ibid.*, 442, pls. viii.—ix.)

E. D. Cope devotes an article to fossil vertebrates from Texas; describing species ranging from the Pliocene to the Trias. (*Proc. Amer. Phil. Soc.*, 1892, 123.)

F. Bassani notices vertebrate remains from the Trias of Dogna, near Friuli, Italy. These include two genera of fishes, the reptilian Placodus, and the scutes of Psephoderma; the position

of the latter among reptiles being still undetermined. (*Rendicont. R. Acc. Lincei.* [5], i. 284.)

In a series of plates, accompanied with descriptive letterpress, **H. N. Hutchinson** attempts the restoration of the external form of a number of extinct animals, mainly vertebrates. (*Extinct Monsters*, 8vo, illust., London, 1892.)

II.—MAMMALS AND BIRDS.

North American.

O. C. Marsh describes mammalian remains from the Laramie of Wyoming, mostly detached teeth. (*Amer. Jour. Science* [3], xliii. 249, pls. v.—xi.)

H. F. Osborn and **J. L. Wortmann** have a memoir on the mammals from the Wahsatch and Wind River Eocene. Attention is directed to the homology of the secondary cusps on the molars of Ungulates; while another portion is devoted to the transition between the cheek-teeth of certain primitive carnivores and modern cats. A third part relates to the classification of Peris sodactyle Ungulates, in which it is urged that a phylogenetic system should be followed, so that the Eocene Hyracotherium, as well as the horse, should be included in the Equidæ. (*Bull. Amer. Mus. Nat. Hist.*, iv. 81, pl. iv.)

E. D. Cope describes some new Tertiary mammals; among them a hyæna-like form (Borophagus), and an extinct genus of cat and another of weasel. (*Amer. Nat.*, xxvi. 1028.)

South American.

H. Burmeister publishes a critical memoir on extinct mammals of Argentina. The first section relates to the Ungulate Nesodon, and the author finds that a number of species and genera have been formed from the remains of a single species. It is shown that the alleged occurrence of enamel in the teeth of some Tertiary Edentates is incorrect. After the description of a new Megalonyx the memoir concludes with a notice of the Cetacean Saurodelphis, allied to Inia. (*Annal. Mus. Buenos Aires*, iii. 401, pls. viii. —ix. [1891].)

European.

A. Nehring records 14 species of small fossil mammals from a cave near Schaffhausen. (*Verh. Anthrop. Ges.*, 1892, 86.)

A. Hofmann continues his investigations of the miocene mammals of Styria, describing remains of two Carnivores, a Shrew, a Rodent, and a Chevrotain. (*Jahrb. Geol. Reichs. anst.*, xlii. 63, pls. ii.—iii.)

C. Depéret publishes a revision of the miocene mammals from La Grive, St. Alban, and other localities in the Rhone basin, with descriptions of new forms. Chalicotherium and Macrotherium, which are shown to be distinct, are regarded as fossorial Perissodactyle Ungalates. (*Archiv. Mus. Lyon.*, v. 1, pls. i.—iv.)

The same author continues his researches on the fossil mammals of the Pliocene of Roussillon, describing certain Carnivores, Rodents, Ungulates, and the monkey Dolichopithecus. This part also contains descriptions of the fossil birds of this formation, which are noticed below. (*Mém. Soc. Géol.—Pal.*, iii. 117, pls. i.—ii.)

L. Rütimeyer has remarks on the Oligocene mammals of Egerkingen, referring to his own earlier work in connection with the homology of the cusps of molar teeth. (*Verh. Nat. Ges. Basel.*, x. 101.)

The same author contributes a monograph on the mammals of the above-named deposits. A considerable portion deals with the classification of Ungulates, these being divided into Trigodonts, or those with triangular three-cusped upper molar teeth, and Zygodonts, or those having quadrangular upper molars. A number of new forms (some allied to North American types) are described; and the nomenclature or serial position of others is revised. (*Abhandl. Schweiz. Pal. Ges.*, xviii. 1, pls. i.—viii.)

C. J. F. Major discusses the fossil vertebrates of Samos. Attention is directed to the systematic position of Chalicotherium. The notice concludes with a discussion as to the age of the deposits of Samos, Pikermi, and Maragha, which are regarded as upper Miocene. The Siwaliks are considered to be later, and more related to the Pliocene of the Val d'Arno. A list of the vertebrates of Samos is given. (*Samos*, Lausanne, 1892, 4to.)

African.

A. Pomel has notices of the Pleistocene and Pliocene mammals of Algeria and Tunis. The most interesting is a giraffe-like animal allied to Helladotherium, from the lower Pliocene, for which the name Libytherium is suggested. Pleistocene types include a monkey referred to Macacus, a Rodent allied to Arvicola, but with rooted teeth of simpler structure, described as Bramus; a new Cervus, and an antelope allied to Cobus, as well as several mammals still living in Africa. (*Comptes Rendus*, cxiv. 53 and 1159, and cxv. 100 and 213.)

Primates.

A. Gaudry has observations on remains of a monkey from a

cavern in the Haute-Garonne. These appear to be the first indications of the existence of Primates in the Pleistocene of the Continent. (*Comptes Rendus*, cxv. 1236.)

Carnivores.

R. Lydekker notices that a civet (Viverra) is common to the Oligocene of Hordwell and the Phosphorites of France. (*Quart. Jour. Geol. Soc.*, xlviii. 373.)

Rodents.

E. T. Newton gives a description of the skull of the Gigantic Beaver (Trogontherium) of the Forest-bed, of which a notice appeared in 1891. (*Trans. Zool. Soc.*, xiii. 165, pl. xix.)

Ungulates.

W. B. Scott publishes a memoir on the horse-like Mesohippus and the Traguline Leptomeryx. The former is regarded as one of the ancestors of the horse, and distinct from the European Anchitherium, which is considered to be an offshoot. After the descriptive portion, there is a discussion as to the part "parallelism has played in mammalian evolution. (*Jour. Morphology*, v. 301, pls. xii.—xxiii. [1891].)

H. Pohlig monographs the deer of the Thuringian travertine, with reference to their relationship to existing species, of which they merely form varieties. (*Palæontographica*, xxxix. 215, pls. xxiv.—xxvii.)

A. Nehring describes the skull of a variety of the extinct Irish Deer, approximating to the Fallow Deer. (*Sitz-Ber. Nat. Fr. Berlin*, 1892, 3, and *Deutsche Jäger-Zeitung*, xviii.)

R. Lydekker notices a skull of Dacrytherium from the French Phosphorites, which turns out to be identical with Dichobune ovina from the Oligocene of the Isle of Wight. (*Quart. Jour. Geol. Soc.*, xlviii. 1, pl. i.)

O. C. Marsh notices the presence of polydactylism in existing horses. The additional digits are regarded as atavistic features. The paper concludes with a description of the feet of a number of extinct Perissodactyle Ungulates, with a discussion of the phylogeny of the horse. (*Amer. Jour. Science* [3], xliii. 339.) This memoir is criticised by **Cope** (*Amer. Nat.*, xxvi. 410.)

Marsh also describes five-toed Ungulates from the Eocene of North America, regarded as indicating a new order, Mesodactyla. (*Amer. Jour. Science* [3], xliii. 445.)

H. F. Osborn discusses the affinities of the Perissodactyle Ungulates from the European Eocene included in Lophiodon, and concludes that they indicate four genera and as many families.

The typical forms, like L. parisiensis, have no American analogues. L. annectans is considered to be allied to the American Isectolophus, which is placed with the Tapirs; while L. cartieri and L. rhinocerodes are respectively affiliated to Hyrachyus and Amynodon, the former belonging to the Hyracodontidæ and the latter to the Rhinoceroses. (*Amer. Nat.*, xxvi. 763.)

Madame M. Pavlow has a memoir on the fossil rhinoceroses of Russia, and the phylogeny of the group. The woolly rhinoceros is considered to be allied to the Leptorhine species, and not to the living African Burchell's rhinoceros. One of the European Oligocene species is referred to the North American Amynodon. The phylogeny of the family is illustrated by a table. (*Bull. Soc. Moscow*, 1892, 147, pls. iii.—v.)

C. Earle has a memoir on the North American Palæosyops and its allies. It is shown that these Perissodactyles are so closely allied to the larger horned forms from the Miocene described as Titanotherium, that the latter must be regarded as the descendants of the former, and the whole included in a single family. The phylogeny is thus brought into harmony with the geological sequence of the forms; the specialisation increasing from the earliest to the latest developments. (*Jour. Acad. Philadelphia*, ix. 267, pls. x—xiv.)

H. F. Osborn writes a discussion on the structure of the foot of the five-toed Eocene Ungulate Meniscotherium, and comes to the conclusion that it is allied to Chalicotherium. (*Amer. Nat.*, xxvi. 507.)

C. Earle revises the American species of Coryphodon, pointing out in what manner the molars resemble those of other Ungulates. He reduces the number of nominal species. (*Bull. Amer. Mus. Nat. Hist.*, iv. 149—166.)

H. Hicks records the occurrence of Mammoth, Horse, and Red Deer in a loam-bed in Endsleigh Street, London. The deposits overlying are regarded by Dr. Hicks as glacial; and it is inferred that the animals lived on that area during the early part of the Glacial period. (*Quart. Jour. Geol. Soc.*, xlviii. 453; *see* also p. 279.)

Sirenians.

R. Lydekker describes part of the upper jaw of a Sirenian from the Italian tertiary, remarkable for the structure of its molars. These teeth show a structure resembling a degenerate modification of the type obtaining in Selenodont Artiodactyle Ungulates; and it is inferred that Sirenians are allied to Artiodactyles with that type of tooth-structure. In the course of the paper it was

shown that Halitherium veronerse should be transferred to Prorastoma, previously known by a skull from the Tertiary of Jamaica. (*Proc. Zool. Soc.*, 1892, 77.)

Cetaceans.

F. P. Morenó gives an account of the skulls of two Cetaceans from the Tertiary of Argentina, regarded as indicating as many new generic types, seemingly allied to the Dolphins. (*Rev. Mus. La Plata*, iii. 389, pls. x.—xi.)

Marsupials.

C. W. de Vis publishes remarks on the fossil Wombats of Australia, in which he denies that the chisel-like incisors described as Sceparnodon pertain to Phascolonus. (*P. Linn. Soc. N.S.W.* [4], vi. 235 [1891].)

The same author has further observations on the incisors of Sceparnodon. (*Ibid*, 258, pl. xxii.)

He also enters upon the question of the affinity of Nototherium to the allied genera. (*Ibid.*, 159.)

E. D. Cope describes (as Thlœodon) a jaw from the Laramie, considered to indicate a marsupial or monotreme. (*Amer. Nat.*, xxiv. 758.)

Birds.

O. C. Marsh describes the coracoid of a bird from the Laramie of the United States, under the name of Cimolopteryx. (*Amer. Jour. Science* [3], xliv. 175, pl. iii., fig. 2.)

F. Ameghino revises the fossil birds of Argentina. The number of genera and species proposed by Moreno and Mercerat is shown to be excessive; and some other emendations are made. Certain new forms, however, are described. (*Riv. Argent. Hist. Nat.*, i. 441 [1891].)

C. Depéret has a memoir on the Pliocene birds of Rousillon. Five species are recorded, namely, a Corvus, a thrush, three Gallinaceous forms, and an Anserine. Their affinities appear to be with living Indo-Malayan types. (*Comptes Rendus*, cxiv. 690; and *Mém. Soc. Géol., Pal.*, iii. 117, pl. iii.)

R. Lydekker describes a series of bird-bones from the Pleistocene of Sardinia and Corsica. The named forms are referred to existing genera and species. The whole fauna is of an African type. (*Proc. Zool. Soc.*, 1891, 467, pl. xxvii. [1892].)

The same author has notes on remains of a stork from the Allier Oligocene, referred to Propelargus. (*Ibid.*, 476—479.)

A. Milne-Edwards describes bird-remains from the Phosphorites of France. They include an eagle, an extinct genus of owl, several extinct generic types of Passeres and Picarians, a sand-

grouse, and two species of the extinct genus Palæortyx, an extinct crane-like genus (Geranopsis), a heron, two species of rail, and several extinct generic types of Ralline birds. The Passerine genus Tachyornis had been described by Lydekker as Ægialornis, which has precedence. (*Compte Rendu d. 2me Congrés ornithol. internat.*, 21 pp.)

C. W. de Vis continues his researches on the birds of the superficial deposits of Queensland. The bones described are mostly fragments, and are considered to indicate an extinct genus of Accipitrines, an extinct Tribonyx, a Porphyrio, and a Gallinula, an extinct genus of storks (Palæopelargus), a Spoonbill, a Pelican, and an Emeu. Of wider interest is the alleged occurrence of a Kiwi (Apterygidæ). The paper concludes with a list of birds described from these deposits. (*Proc. Linn. Soc., N.S.W.* [2], vi. 437, pls. xxiii., xxiv.)

H. O. Forbes describes fossil birds from New Zealand and Chatham Island. Among those from the mainland is a new genus of Moa—Palæocasuarius—and a species of Cereopsis. From Chatham Island the most interesting is a species of Aphanapteryx, previously recorded only from Mauritius. (*Trans. New Zealand Inst.*, xxiv. 185.)

F. W. Hutton contributes a memoir on the Moas. It is concluded that they should be arranged in seven genera, Dinornis, Palapteryx, Anomalopteryx, Cela, Mesopteryx, Syornis, and Euryapteryx. This arrangement differs from other classifications, owing to the circumstance that, according to the author, some of the species in the British Museum collection have the wrong skulls assigned to them. The genera are classified by the characters of the skull, supplemented by those of the sternum; and it is considered that one of the species retained a rudimentary wing. The number of species admitted is 25; most of these are from superficial deposits, although one Anomalopteryx is regarded as Pliocene or Miocene. The Moas are considered to be related to Emeus, Cassowaries, and Kiwis; but are regarded as nearer to the Carinates than are any other flightless birds. An hypothesis is offered as to their origin, and also as to their great development. In the North Island it is considered that they were exterminated four or five centuries ago, while in the South Island they may have lingered a century longer. (*N. Zeal. Jour. Science*, i. 247; and *Trans. N. Zeal. Inst.*, xxiv. 93, pls. xv.—xvii.)

The same author has observations on the origin and relationships of the various extinct groups of Ratite birds. (*Rep. Austral.* c., 1892, sec. D, art. 1.)

A. Hamilton discusses the stones presumed to have been carried by the Moas in their gizzards. (*Trans. New Zeal. Inst.*, xxiv. 172.)

The same writer records further specimens of the Ralline Aptornis, and shows that many of the remains referred to it belong to other forms. (*Ibid.*, 175.)

R. Lydekker describes Moa bones regarded as indicating a new species—*Pachyornis rothschildi*. (*Proc. Zool. Soc.*, 1891, 479, pl. xxxviii. [1892].)

H. C. Field notices the discovery of Moa bones associated with stone implements, and regards them as of recent date. (*Trans. New Zeal. Inst.*, xxiv. 558.)

R. W. Shufeldt describes and figures bird-remains from the upper Tertiary of Oregon. (*Jour. Acad. Philad.* [2], ix. 389, pls. xv.—xvii.)

III.—REPTILES.

General.

E. D. Cope describes the homologies and relations of the bony arches in the posterior region of the skulls of reptiles. He mainly refers to extinct forms; and shows how the skulls of all reptiles may be derived from the completely roofed skulls of Labyrinthodonts by a kind of trephining process. Diagrams of the skulls of the various orders show the arrangement of these foramina and of the adjacent bony arches. (*Trans. Amer. Phil. Soc.*, xvii., 1, pls. i.–v.; and *Amer. Nat.*, xxvi. 407, pls. xv. –xvii.)

Dinosaurs.

E. T. Newton describes an Iguanodont tooth obtained from the chalk near Hitchin, referred to Iguanodon. (*Geol. Mag.* [3], ix., 49.)

H. G. Seeley has notes on the pelvis of Polacanthus from the Wealden. It is inferred that this Dinosaur was more nearly allied to Stegosaurus and Omosaurus than had been hitherto supposed, and that its relationship to Hylæosaurus was close. (*Quart. Jour. Geol. Soc.*, xlviii. 81.)

R. Lydekker describes the pelvis of an Armoured Dinosaur from the Wealden, referred to a second species of Polacanthus, distinguished by the armour being smooth. It is pointed out that the name Polacanthus is inadmissible. (*Ibid.*, 148.)

The same author has notes on the foot bones of a Sauropodous Dinosaur from the Wealden. (*Ibid.*, 375.)

E. D. Cope describes the skull of Lælaps, of the Laramie,

stating that the American Ceratosaurus is inseparable from the European Megalosaurus. (*Proc. Amer. Phil. Soc.*, xxx. 240.)

O. C. Marsh describes the skull of a Dinosaur from the Laramie, characterised by the presence of oval vacuities in the posterior border, and hence named Torosaurus. (*Amer. Jour. Sci.* [3], xliii. 81, pls. ii.–iii.)

The same author states that the bird-like Dinosaur described as Ornithomimus belongs to the carnivorous and not to the herbivorous group. (*Ibid.*, 451.)

He has also a paper on the Triassic Dinosaurs of Europe and North America, in which it is shown that while the English Thecodontosaurus and the American Anchisaurus are related, they are distinguished by the shape of the coracoid, which is entire in the former but fenestrated in the latter. (*Ibid.*, 543, pls. xv.–xvii.)

In a fourth paper **Marsh** contrasts the limb-bones of the Cretaceous Claosaurus with those of the Jurassic Stegosaurus and Camptosaurus. It is shown that in the latter the ilium had an anterior process, as in Iguanodon. Teeth from the Laramie are described, some of which are reptilian, while others may prove to be mammalian. Restorations of the limbs of several Dinosaurs are given. (*Ibid.*, xliv. 171, pls. ii.–v.)

E. D. Cope describes Dinosaurian remains from the Laramie. Some are referred to the new genera Manospondylus and Claorhynchus, while others are assigned to Agathaumas and Pteropelyx. Claosaurus, Marsh, is declared to be identical with the latter. (*Amer. Nat.*, xxvi. 756.)

O. C. Marsh gives restorations of the skeletons of Claosaurus and Ceratosaurus, maintaining their distinctness from the genera with which they are identified by Cope. (*Amer. Jour. Sci.* [3], xliv. 343, pls. vi.–vii.)

H. G. Seeley publishes an epitome of a paper on the Saurischian Dinosaurs of Europe. It is considered that the genus Belodon is nearly allied to the Cetiosauria, while Stagonolepis is equally nearly related to the Megalosauria. The European Triassic Zanclodon, Thecodontosaurus, and Palæosaurus, are then discussed; after which there is a notice of Massospondylus, Euscelesaurus, and other South African forms. In conclusion it is considered that Pterodactyles are quite as nearly related to the Sauropodous and Theropodous Dinosaurs as are birds to the Iguanodonts. (*Proc. Geol. Soc.*, 1892, 188.)

Crocodilians.

G. Capellini publishes a memoir on the skull of the long-

snouted Crocodile from the Tertiary of Cagliari, of which he had given a preliminary description previously, and named Tomistoma calaritanus. (*Atti. Ac. Lincei. Rom.* [4], vi. 507, pls. i.–iv.)

Lizards and Serpents.

A. Gaudry has a preliminary note on some Mosasaurian remains from the Cretaceous of France. (*Comptes Rendus,* cxiv. 1236.)

O. C. Marsh describes remains of a snake from the Laramie of Wyoming as Coniophis; this being the second recorded instance of the occurrence of ophidians in strata older than the Eocene. He likewise records a lizard from the same horizon. (*Amer. Jour. Sci.* [3], xliii. 450.)

Rhynchocephalians.

L. Dollo contributes information on the structure and affinities of the long-snouted, and probably aquatic, Rhynchocephalian Champsosaurus from the lower Eocene of Belgium; and in the course of the memoir amends the classification of the Rhynchocephalian order. (*Bull. Soc. Belg. Géol.*, v. 53, pls. vi.–viii.)

Ichthyosaurians.

E. Fraas publishes a note on the skeleton of an Ichthyosaur from the Lias of Württemberg, with the contour of the soft parts preserved. This confirms the existence of a tail-fin, and also demonstrates that the back was furnished with an erect triangular fin, behind which came a series of horny excrescences. The tail-fin is vertical, and is externally symmetrical, although the extremity of the vertebral column is continued into the lower lobe. (*Jahrb. f. Min.*, 1892, ii. 87; *see* also *Nat. Sci.*, i. 514.)

The same author describes an Ichthyosaur from the middle Lias of Württemberg, presenting characters intermediate between upper and lower Liassic types. (*Jahresh. Ver. Vat. Naturkunde Würt.*, 1892, 22, pl. i.)

[For PECTORAL GIRDLE, *see* under next heading.]

Plesiosaurians.

H. G. Seeley discusses the structure of the pectoral girdle in the Plesiosaurs, with a notice of that of the Ichthyosaurs. It is inferred that in the latter there was a cartilage in advance of the coracoid, and internal to the front half of the scapula representing the precoracoid of Anomodont reptiles. After a review of different theories of the shoulder-girdle in the Plesiosaurs and their allies, it appears to be concluded that while the median expansions of the scapulæ in certain forms simulate precoracoids, they cannot be definitely regarded as such, but may be inward

growths of the scapulæ corresponding to the forward extensions of the coracoids. It is further inferred that the median element found in the pectoral girdle of the Plesiosaurs is of tripartite origin, and represents the interclavicle and clavicles, having no correlation with the omosternum. This compound element is correlated with the clavicular bar of the Nothosaurs. A discussion follows as to the generic character of the Jurassic and Cretaceous Plesiosaurs, which are considered to represent a separate family, Elasmosauridæ. Some forms regarded as new are described, and modifications of previous classifications suggested. Other observations relate to the identification of Rhomaleosaurus with Thaumatosaurus, which is not accepted. The paper concludes with a new scheme of classification, in which the order is divided into two main groups, according as to whether the ribs articulate by two heads or by one. The former group is subdivided into a long-necked section, represented by Plesiosaurus and Eretmosaurus; and a short-necked section, including Rhomaleosaurus and Pliosaurus. The second group includes Polyptychodon and the Elasmosauridæ—the latter being represented by nine genera. (*Proc. Roy. Soc.*, li. 119.)

J. W. Hulke contributes a paper reviewing the above conclusions, in which it is urged that there is no evidence of the presence of a precoracoid in Ichthyosaurs; while among Plesiosaurians it is contended that the ventral element of the anterior portion of the pectoral girdle is really a precoracoid, its dorsal moiety representing the scapula of other reptiles. (*Op. cit.*, lii. 233.)

H. G. Seeley describes specimens of Mesosaurians from the Secondary rocks of South Africa. It is considered that the African Mesosaurus is distinct from the South American Stereosternum, as there appears to be a difference in the number of the sacral vertebræ and the mode of junction of the coracoids. It is concluded that the group is closely allied to Neusticosaurus of the Trias of Württemberg; and the author would regard the whole group—Mesosauria—as distinct from the one embracing the Nothosaurs. (*Quart. Jour. Geol. Soc.*, xlviii. 586, pl. xviii.)

The same author describes the skeleton of a reptile from South Africa, apparently allied to the above, as Eunotosaurus. (*Ibid*, 583.)

Anomodonts.

H. G. Seeley describes a skull from the Karoo system of South Africa, regarded as allied to Ælurosaurus. (*Quart. Jour. Geol. Soc.*, xlviii. 469.)

He has also notes on a jaw from the same deposits, referred to

Endothiodon. It is noteworthy on account of the serrated edges of the corners of the teeth. (*Ibid.*, 476.)

Seeley also gives a complete restoration of the skeleton of Pariasaurus, together with a discussion of the affinities of the Anomodonts, among which the Mesosauria are included. (*Phil. Trans.*, clxxxiii., B. 311, pls. xvii.—xxix.)

G. B. Howes discusses the shoulder-girdle of some of the Dicynodonts, and makes certain emendations on previous determinations of the homology of some of its elements. (*Jour. Anat. Phys.*, xxvi. 403.)

E. T. Newton publishes an announcement of the discovery of a Dicynodont fauna in the Trias of Elgin, several of the forms being apparently allied to those from South Africa and India. Another reptile suggests affinity with the South African Pariasaurus. (*Geol. Mag.* [3], ix. 515.)

IV.—FISHES.

General.

A. S. Woodward has a paper on the evolution of the fins as deduced from extinct forms. It being evident that the median fins are essentially the same in structure as the paired fins, while it is known that the former arise from a longitudinal fold of skin, it is inferred that the latter originate from two lateral folds of the same nature. The development of the fins of the two systems follows a nearly identical course, except that there are two modes of reduction in median fins, against one in the paired fins. It remains a problem why both the dorsal and lateral folds, when subdivided by concentration, persist only at two points. (*Nat. Science*, i. 28.)

The same author contributes remarks on the lowest types of Vertebrate animals. Reference is made to the limbless Palæospondylus from the Old Red Sandstone, which is probably allied to the Lampreys. The author then discusses Pteraspis and Cephalaspis and their allies; and from the fact that in Acanthaspis the pectoral appendages are united with the dorsal shield, suggests that these are not comparable with the limbs of the higher fishes. (*Ibid.*, i. 596.)

In a third memoir **Woodward** draws attention to the mode of evolution of sharks' teeth. In those forms with forked teeth, like Diplodus, it is considered that there has been a union of two distinct cusps, while in those with large plate-like teeth covering a considerable area, not only a number of adjacent teeth, but likewise those belonging to several successional series, have coalesced. On the other hand, in Notidanus and its allies there

is evidence of the linear multiplication of successional cusps. (*Ibid.*, 672.)

North American.

E. D. Cope has a memoir on the characters of North American Palæozoic fishes. Part relates to the gigantic Macropetalichthys, formerly considered to be allied to the Sturgeons. The author confirms the opinion that this genus really belongs to the Arthrodiran section of the Dipnoans. Several Elasmobranchs are described. (*Proc. U.S. Nat. Mus.*, xiv. 447, pls. xxviii.—xxxiii. [1891].)

The same author has a paper on the Palæozoic fishes of Pennsylvania, with a notice of a skull of Megalichthys from the Carboniferous of Kansas. Several new species belonging to various genera are described. (*Proc. Amer. Phil. Soc.*, xxx. 221, pls. vii., viii.)

C. D. Walcott issues notes on the discovery of vertebrate remains in the Silurian (Ordovician) of Colorado, these being referred to Octracoderms, Elasmobranchs, and Chimæroids. (*Bull. Amer. Geol. Soc.*, iii. 153, pls. iii.—v.)

A. S. Woodward describes fish-remains from the Devonian of Quebec, including Elasmobranchs, a Cephalaspis, the allied Phlyctænaspis, a new Coccosteus, and a new Diplacanthus. The supposed jaw-plates of Bothriolepis are shown to belong to the head-shield. The close relationship of the fauna to that of the Russian Devonian is pointed out. (*Geol. Mag.* [3], ix. 1, and 481, pls. i. and xiii.)

European.

F. Bassani contributes a memoir on the fish from the schists of Mont Peltine, near Salerno, regarded as Triassic. They include Cœlacanthus, Belonorhynchus, Pholidophorus, Peltopleurus, Dapedius, and Lepidotus. (*Mem. Soc. Ital. Sci.* [3], ix. 1.)

A. S. Woodward publishes observations on the fishes of the English lower Oolites. Five species, belonging to as many genera, are described, the most interesting being a skull of Mesodon from the Great Oolite of Kingsthorpe, showing the bones of the head and the teeth. (*Proc. Geol. Assoc.*, xii. 238, pl. iv.)

Ostracoderms.

E. W. Claypole remarks on the structure of the Silurian American Palæaspis, with observations on the family to which it belongs. A restoration of one species is attempted, and a new definition of the genus given. (*Quart. Jour. Geol. Soc.*, xlviii. 542.)

J. V. Rohon publishes a memoir on the structure of Pteraspis, in which it is pointed out that the shield is histologically similar to that of Pteraspis, and different from that of Coccosteus. (*Verh. Russ. k. Mineral. Ges. St. Pétersb.*, xxviii. 25, pl. vii. [1891].)

The same author describes remains of Tremataspis and Thyestes (= Auchenaspis) from the Silurian of Oesel, with illustrations of their internal structure. (*Mém. Ac. St. Pétersb.*, xxxviii., No. 13, 2 pls.)

(See also **Woodward**, *supra*, p. 293.)

Elasmobranchs.

A. S. Woodward makes a contribution to our knowledge of the Hybodont and Cestraciont Sharks of the Cretaceous. It is shown that one of these is a typical Hybodus, while a second belongs to Synechodus, a third confirming the existence of the Australian Cestracion in the Cretaceous. (*Proc. Yorks. Geol. Soc.*, xii. 62, pls. i., ii.)

The same writer describes the structure of the Cretaceous Sawfish (Sclerorhynchus), which is shown to be a primitive type with a ray-like body. (*Geol. Mag.* [3], ix., 529.)

E. T. Newton records the occurrence of Onychodus in the Devonian of Scotland. (*Geol. Mag.* [3], ix. 51.)

R. Etheridge and **A. S. Woodward** record Belonostomus in the Cretaceous of Queensland. (*Trans. R. Soc. Victoria*, for 1891, 1, pl. i.)

A. R. Crook describes remains of saurodont fishes from the Cretaceous of Kansas, referable to the families Stradontidæ, Protosphyrænidæ, and Ichthyodectidæ, the latter being represented by the genera Portheus, Daptinus, and Ichthyodectes. (*Palæontographica*, xxxix. 107, pls. xv.—xviii.)

O. M. Reis discusses the osteology and systematic position of the genera Belonorhynchus and Tetragonolepis. (*Geognostische Jahreshefte* for 1891, 143 [1892].)

Teleostomes.

O. M. Reis describes the Cœlacanths, dealing with the general osteology, the bones of the head, the nature of the integument, and the internal organs. Restorations are given of two species belonging to Undina. (*Inaugural-Dissertation k. Universität z. München*, Munich, 1892, 2 pls.)

A. Andreæ has notes on the occurrence of the existing American Lepidosteus (Garpike) and Amia in the Miocene of Mayence; and concludes with some observations on the relationship between the fauna of these beds and that of some of the American Tertiaries. (*Verhandl. Nat. Med. Vereins, Heidelberg* [2], v. 1).

Chimæroids.

A. S. Woodward records new types of Chimæroids from the English Oxford and Kimmeridge Clays, exemplified by specimens of jaws and teeth. Two indicate new genera—Pachymylus, and Brachymylus, while the third belongs to Elasmodectes, hitherto known from the Cretaceous. (*Ann. Mag. Nat. Hist.* [6], x. 13, pl. iii.)

The same writer describes the skeleton of a Chimæroid (Ischyodus) from the Oxford Clay of Christian Malford, which is the first example of a skeleton from English rocks. (*Ibid.*, ix. 94.)

Dipnoans.

E. W. Claypole describes a gigantic fish (Gorgonichthys) from the Devonian of Ohio, allied to Dinichthys; the length of its jaw being 25 inches. (*Amer. Geol.*, x. 1.)

PALÆONTOLOGY (INVERTEBRATE).

By J. W. GREGORY, F.G.S.*

The work on Invertebrate Palæontology during 1892 does not appear to have been rewarded by the description of any fossils with very novel characters, or of any very special systematic interest. The year, however, has seen several important monographs on groups which, owing to the rarity of specimens, or the difficulty of study, have previously been neglected; such are Dr. Rust's monograph on the Radiolaria, and Hinde and Holme's memoir on the sponge deposits of Oamaru in New Zealand. The most striking character of the year's work, however, is the increasing importance attached to the study of faunas as distinct from species: the abandonment of the doctrine of special centres of creation and the acceptance of evolution have been rather tardily followed by the practical recognition of the fact that, as species result from adaptation to environment, similar conditions may lead to the independent evolution of forms specifically indistinguishable along quite different lines. Hence the occurrence of the same species of brachiopod, for example, in two distinct areas, need not be proof of the original connection of those areas, either directly or through any locality in

* Mr. Gregory left England for Eastern Africa early in November: the Editor is indebted to T. T. Groom, Esq., F.G.S., for completing the work; also to F. A. Bather, Esq., F.G.S., for contributing notes on the Cystideans, Crinoids, and Brachiopods, and for help in revision.

connection with both. The necessity has therefore become apparent for the study and comparison of faunas, rather than of species, in the opinion of those palæontologists who have adopted these views. (See, however, p. 301.)

Many important gaps in our knowledge of palæozoological distribution have been filled in by the description of fossil faunas from little-known regions; such are the welcome additions made to our knowledge of the Lower Mesozoic faunas of Malaysia by Dr. Rothpletz, to the American Devonian faunas by Steinmann and Ulrich's description of fossils from Bolivia, or to the general palæontology of the Southern Andes by Behrendsen, and of Asia Minor by Bittner.

Another series of papers which deserve especial mention are those which owe their interest to the horizon from which the fossils came, and their consequent geological evidence. Foremost amongst these is the remarkable discovery by Parma of Radiolaria in a series of schists in the Cottian Alps, which have been assigned to the Upper Archean. Prof. Barrois has also discovered a series of Radiolaria in beds which are probably truly Precambrian.* To the same category belong the papers in which Col. J. F. N. Delgado has recorded the discoveries of fossils in some of the older Palæozoic rocks of Portugal, and the numerous papers on the Olenellus fauna roused by the interest excited by the great monograph of Mr. Walcott, published in 1891. The description of a new echinoid from Barbados may also be mentioned, as it helps to fix the latest date for the famous deep-sea radiolarian beds of that island.

SYSTEMATIC SUMMARY.

General and Indexes.

H. S. Williams. "The Scope of Palæontology and its Value to Geologists"—(*Amer. Geol.*, x. pp. 148—169)—the Presidential Address to the Geological Section of the American Association for the Advancement of Science.—In this Prof. Williams enunciates the principles which must guide geologists in the application of the facts of palæontology, and on which he has proceeded in the first of the series of Correlation papers (that on the Devonian) issued last year by the American Geological Survey. He points out that the simple methods of correlation by mere percentages of species will hold no longer, as bathymetrical differences within 50 miles may swamp those due to age or

* At the meeting of the British Association in Edinburgh, Prof. Sollas gave an account of some structures which he had detected in the slaty rocks of Howth (co. Dublin) and thought were probably Radiolaria.

European.

H. Hicks. "The Fauna of the Olenellus Zone in Wales." (*Geol. Mag.* [3], ix. 21.)—A short paper arguing that the little available palæontological evidence shows that the Olenellus zone is represented both in North Wales and in the Caerfai group of St. David's.

S. Wohrmann and **E. Koken.** "Die Fauna der Raibler Schichten vom Schlernplateau." (*Zeit. deutsch. Geol. Gesell.*, xliv. 167, pl. vi.—xvi.)—An extensive addition to the knowledge of one of the richest and most interesting faunas of the Trias of Central Europe.

E. Schellivien. "Die Fauna des karnischen Fusulinenkalks." (*Palæontograph.*, xxxix. lief. i.)—This is of value owing to the important additions to the knowledge of the anatomy of the Carboniferous Foraminifera.

M. Koch. "Uber Petrefactenkunde und Zusammensetzung der Quartzitablagerungen im Bruckberg-Ackern-Gebiet." (*Jahrb. k. Preuss. Geol. Landes. und Bergakad*, Berlin (1890), Bd. xi., 1892, 32.)—The discovery of these fossils enables the author to render more precise the subdivision and correlation of the great Devonian quartzites of the Harz Mountains; he divides these into three zones.

C. Barrois recognises in the fossils found by Almera, in the neighbourhood of Barcelona, forms belonging to a number of horizons in the Ordovician, Silurian, and Hercynian formations. The Devonian fauna is a new one, and shows unexpected relations with that of Thuringia. Similar relations are seen in the case of the Silurian and Ordovician deposits of the two regions. The resemblances between the Palæozoic beds of Catalonia and Thuringia are in harmony with the generalisation, made by Lapworth, that the Silurian of the West of Europe, when traced from N.E. to S.W., does not vary, but changes in thickness and in the

character of its fauna when traced from N.W. to S.E. (*Soc. Géol. du Nord*, xx. 61.)

E. Stolley. "Die Kreide Schleswig-Holsteins." (*Mitth. Min. Inst. Univ. Kiel*, i. 191.)—In this memoir the author gives a full list of the fossils of the Schleswig-Holstein Chalk; a good many new species are described, and a number of little-known ones rediagnosed and figured. Several interesting echinoids are included, though the limits of specific variation are more restricted than most English writers would admit.

Extra-European.

P. Thomas. "Étage miocene et valeur stratigraphique de l'Ostrea crassissima au sud de l'Algérie et de la Tunisie." (*Bull. Soc. Géol. France* [3], xx., no. 1, 3.)—In this memoir M. Thomas continues his descriptions of the Tunisian fauna, and discusses whether *Ostrea crassissima*, which has been found of such value as a zonal fossil in the Miocenes of southern Europe, is equally reliable in Africa.

O. Behrendsen. "Zur Geologie des Ostabhanges der argentinischen Cordillere. Th. ii." (*Zeit. deutsch. Geol. Gesell.*, xliv., hft. i. 1, pl. i.—iv.)—The Devonian fauna of Bolivia, and the Neocomian fauna of the northern Andes have long been known to geologists through the collections of Forbes and Karsten. Dr. Behrendsen now describes a series of fossils which supplement earlier records. The most interesting part of the present paper is the description of the Jurassic faunas. The vast series of sandstones in South America assigned to this period have not as yet yielded fossils; the fauna is of interest since the succession of the Ammonite zones is identical as far as it goes with that of Europe.

A. Ulrich. "Palæozoische Versteinerungen aus Bolivien." (*Neues. Jahrb.*, viii., hft. i. 1, pl. 1—5).—Dr. Ulrich describes a rich fauna of Devonian fossils which were collected by Prof. Steinmann. The majority are Brachiopoda. The fauna is of great geological interest, as from it originated the Middle and Lower Devonian faunas of New York, and other of the eastern States of America.

A. Rothpletz. "Die Perm-, Trias-, und Jura-Formation auf Timor und Rotti im Indischen Archipel." (*Palæontographica*, xxxix., lief. 2, 57, pl. 9—14.)—This fauna is of considerable interest as filling up the gap between the Triassic and Jurassic faunas of India on the east, and Australia on the south. Some connection between these areas is unquestionable; in Eocene times a fauna migrated from India to Australia, and this

apparently did not go round by Malaysia, as the Javan and Bornean faunas do not yield many of the connecting genera. It is therefore important to trace if the shallow water connection between India and Australia then lay along the Malay Archipelago, or whether it followed the great southern continent, which is believed to have connected India, Australia, and South Africa in Triassic times.

C. R. Keyes describes a Kinderhook fauna intercalated in the middle of the Burlington limestone: it furnishes an instance of a lower fauna appearing suddenly in the midst of a higher one, and is regarded by the author as giving a striking illustration of Barrande's doctrine of colonies. (*Amer. Journ. Science*, xliv. 447.)

SYSTEMATIC.

Foraminifera.

Ernesto Mariani. "Il calcare liasico di Nese in Val Serrano." (*Bull. Soc. Geol. Ital.*, x. [1891, 1892], 717, 1 pl.)—As marine Triassic faunas are rather scarce in Europe, the first mesozoic bed which yields a rich supply of marine fossils is the Lias, and careful monographs of the fossils of this horizon are therefore always worthy of note.

Radiolaria.

D. Rüst. "Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen der Trias und der palæozoischen Schichten." (*Palæontographica*, xxxviii. 107.)—This paper has already been referred to as one of the most important of the year, as it marks a distinct epoch in the history of the fossil Radiolaria. Dr. Rüst describes a number of distinct faunas ranging from the Cambrian to the Trias; at the same time he completely revises our knowledge of the whole of the palæozoic species; he enumerates the members of the different faunas, amends the classification, and adds a table of distribution. The monograph is illustrated by an extensive series of plates, which show the great range and complexity which the palæozoic species attained.

A second paper by the same author, D. Rüst—"Contributions to Canadian Micro-Palæontology, pt. iv. 101, pls. xiv.—xvi., with introduction by J. B. Tyrrell" (*Geol. and N. H. Survey, Canada*)—describes a small Radiolarian fauna obtained from the Upper Cretaceous (Pierre Formation) of North-Western Manitoba. The fossils occur in a hard siliceous shale, and are in fairly good preservation. Though there are only 16 species, both the orders Nassellaria and Spumellaria are represented. The fact that

13 out of 16 Cretaceous species are new, shows the extent of ou knowledge of this group.

Miscellaneous Protozoa.

Though Mr. Wetherell adds nothing to settle the vexe problem of the affinities of the Xanthidia, he makes an interestin addition to the knowledge of the distribution of this organism ["On the occurrence of Xanthidia (Spiniferrites of Mantell) in th London Clay of the Isle of Sheppey." (*Geol. Mag.* [3], ix. 28.) The specimens discovered are in good preservation, and ma afford the author opportunities for settling their true nature The specimens collected are $\frac{1}{10}$ mm. in diameter, so that they ar about the same size as those of the Chalk.

Spongida.

G. J. Hinde and **W. M. Holmes.** "The Fossil Sponges o Oamaru." (*Jour. Linn. Soc. Zool.*, xxiv., Zoology, 177 pl. 7—15.)—The Tertiary deposits of Oamaru have long bee well known to microscopists owing to the beauty of the diatom which are abundant in them. The authors have now subjected th sponge spicules of the same deposit to a searching investigation They conclude that the deposit is a true deep-sea ooze, formed at depth of about 2,000 fathoms, though it now forms part of th mainland of New Zealand, a conclusion directly opposed to th theory of the permanence of oceans and continents.

J. F. N. Delgado. "Sur la découverte de fossiles Cambrien dans le Alto Alemtego. Contributions à l'étude des terrain anciens du Portugal." (*Lisbon. Commun. Comm. Trab. Geol.* ii., 16 pp., 3 pl.)—In this note is made the first record of th occurrence of the abnormal sponge Archæocyathus in Europe It occurs in a diabase tuff, the lithological characters of whic are described in a supplementary note by A. Bensaude.

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H. A. Nicholson has now completed his important monograph of the British Stromatoporoids. The last portion (the fourth) includes descriptions of the structure of species of Stromatoporella, Hermatostroma, Stachyodes, Amphipora, and Idostroma. In a supplemental note Dictyostroma is removed from the Stromatoporoids. (*Palæontogr. Soc.*, xlvi. 203, pl. 26—29.)

Graptolites.

One of the most striking advances made in stratigraphy of late years consists in the elaboration of the zonal method of work. This method has been applied with eminent success in the case of Graptolites, and in the hands of English and Scandinavian geologists has led to the most important results. Prof. Lapworth has shown that some twenty zones of graptolites can be recognised in Great Britain and elsewhere, and that wherever they occur the same order of superposition is preserved. This conclusion has been completely confirmed by the Scandinavian geologists, and by Mr. Marr for the Lake district. Each species or genus is found to have a definite and limited vertical, and in a large number of cases a wide horizontal range. In face of the important issues involved by these results, **C. Barrois** was induced to study the succession of graptolites in France, and the results of his examination have been most completely to confirm Lapworth's conclusions as to the stratigraphical value of the group. The French graptolites, however, with the exception of those of Languedoc and Normandy, are badly preserved, and do not present a number of faunas comparable with those of the more northern countries. Of the families of graptolites at present known, all are represented in France except the Leptograptidæ, Dicranograptidæ, and Lasiograptidæ.

In Dr. Barrois's memoir, the graptolites of Languedoc, the Pyrenees, Ardennes, Normandy, and Brittany are treated in detail, and the stratigraphy of the region is unravelled by means of the graptolite zones. In the case of each district a history of the progress of discovery is given, and the species occurring are enumerated and briefly described.

In Languedoc the presence of Arenig, Llandeilo, Bala, Tarannon, and Upper Wenlock rocks is indicated, but in this district, as elsewhere in France, typical lower and upper Arenig and Bala graptolite faunas are still undiscovered. In the Pyrenees, the chief feature is the importance of Tarannon beds, which are here of great thickness, and are divisible into the three zones of Monograptus crassus, M. Becki, and M. vomerinus. A similar fauna is found in Thuringia, Bohemia, and Sweden, and the Pyrenean

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types are the same as those of Saxony, Sardinia, and the Alps, while the Tarannon forms common in England are absent. In addition to Tarannon beds, the lower part of the Wenlock is apparently represented. In the Ardennes, with the doubtful exception of the Llandeilo, all the members of the Ordovician and Silurian, from the horizon of Dictyonema sociale to the Ludlow, are represented. In Normandy the graptolites are of Wenlock age. In Brittany the graptolitic deposits include the equivalents of the Llandeilo, Birkhill (Llandovery), Tarannon, and Upper Wenlock beds.

The French graptolites closely resemble, in their mode of occurrence, those found in other regions: they are often limited to certain thin horizons in which they are present in great numbers: their wide diffusion agrees well with the conclusion that they are at one time of life free-floating. The beds in which they occur are of a very definite character, being generally fine soft black shales remarkable for the absence of clastic grains or other indications of a terrigenous origin. They do not form important accumulations, and frequently alternate with beds devoid of graptolites and consisting essentially of organic or chemical deposits. The phtanites of Anjou consist chiefly of silica, alumina, and carbon. The carbon is derived from the graptolites themselves; the silica from organisms with siliceous tests which in some cases can still be recognised as radiolaria and diatoms (Cayeux). These deposits must have been slowly formed in a region free from terrigenous influences and where the conditions were very stable; they appear to be quite analogous to the radiolarian deposits of modern times.

It is a sign of the times that one of the most eminent of continental stratigraphers sees no other course open to him than to throw in his lot with the increasing body of geologists who regard not merely large formations, but the fossil zones composing them, as practically contemporaneous: the graptolite zones furnish no evidence in favour of the migration of faunas: we must not, it is pointed out, lay too much stress on the relatively artificial assemblages of fossil forms we call faunas, but consider the migrations of each species by itself.

The memoir is completed by tables showing the genera and species of graptolites found in France, and the relations of the graptolitic deposits to those of neighbouring countries. (*Soc. Géol. du Nord*, xx. 75.)

G. B. Pritchard describes an enormous Temnograptus (T. magnificus) from a hard black slate containing Dictyonema grande described and figured earlier in the year by **T. S. Hall** (*Proc.*

Roy. Soc. Victoria, iv. 7). The Temnograptus is closely related to T. multiplex from the Skiddaw slate (*Ibid.*, 56).

ARTHROPODA.

General.

H. Bernard. "The Apodidæ." (*Macmillan, "Nature" Series.*) —This work requires notice here, as the author discusses the affinities of the Eurypterids and Trilobites. His main thesis is the evolution of the whole Arthropod group from a worm-like ancestor.

Trilobites.

B. N. Peach and **J. Horne**. "The Olenellus zone in the North-west Highlands of Scotland." (*Quart. Jour. Geol. Soc.*, xlviii. 227, pl. 5.) The authors describe their discovery of representatives of the Olenellus fauna in the north-west of Scotland; a discovery of importance, as it shows the pre-Cambrian age of the Torridon Sandstone. The authors also propose to place Olenellus in a separate group, and regard it as closely allied to the ancestral form from which Trilobites, Limulids, and Eurypterids were derived.

G. A. J. Cole. "The Story of Olenellus." (*Nat. Sci.*, i. 340.) —The paper gives an interesting sketch of the gradual growth of the present knowledge of Olenellus. He lucidly sketches the change from the view of Ford and Walcott, that Olenellus was a degenerate form of Paradoxides, to that which completely reverses the order. The error arose from the Olenellidan beds in New York having been thrown by a thrust plane on to later formations. Brögger's demonstration of the pre-Paradoxidian age of Olenellus in Norway has been found to be applicable universally.

A number of tails of an Asaphus (Megalaspis? Thorntoni n.sp.) have been recognised in the graptolite beds of Central Victoria by **R. Etheridge, jun.** No fossils but Llandeilo graptolites, a phyllopod (Hymenocaris), and a brachiopod (Siphonotreta) had previously been found in these beds; and this collection represented the sum of our knowledge of the Ordovician fossils of Australia proper. Other fossils, including Orthis, Orthoceras, Strophomena, Murchisonia, with bivalves, crinoids, etc., accompanied the trilobite. The pygidium alone of the latter has been found; it appears to differ from that of the Asaphid previously found in Tasmania, which the author is inclined to regard as a Stygina. (*Report Gov. Geol. on Leigh Creek, S. Australia*, 1892, 8—9, with plate.)

ECHINODERMATA.

Cystidea.

P. H. Carpenter's paper "On Certain Points in the Morphology of the Cystidea" (*Jour. Linn. Soc., London Zool.*, xxiv. 1) appeared too late in 1891 for it to be noticed in the "Year-Book" for that date.. Mention must here be made of it, as it is probably more important than any other paper on the Echinodermata which was actually published in the year. Hitherto the Cystidea have been regarded as having no regular arrangement of their plates, and consequently successive phylogenists have been able to discover in them whatever type of Echinoderm ancestor they wanted. Dr. Carpenter has, however, shown that the great majority of them may be compared with those crinoids that possess three circlets of plates in the cup, and that such "dicyclic" forms fall into two groups: one with a six-rayed and one with a five-rayed structure. A ring of orals can also be recognised. In regard to the long-discussed nature of the various apertures, Dr. Carpenter concludes that the central orifice is the mouth, and the large lateral one the anus: between these occur the genital aperture, and beside this the excretory pore.

O. Jaekel has published a valuable elucidation of the natural history and anatomy of the Eugeniacrinidæ, which he renames the Holopocrinidæ, owing to certain resemblances to Holopus in the arm-structure, and other less important details. He bases a large number of new genera on characters which it has been pointed out are of no morphological and of little physiological value. The most interesting part of Dr. Jaekel's paper is that in which he discusses the habitat and mode of life of these Crinoids; he concludes that they are reef-dwellers, and recognises in their frequent changes of form the influence of powerful currents. (*Zeit. Deutsch. geol. Ges.*, xliii. 557.)

D. Oehlert. "Description de deux Crinoïdes nouveaux du Devonien de la Manche." (*Bull. Soc. Géol. France* [3], xix. 834, pl. xviii.)—One of the two new crinoids is a species of Ctenocrinus, the other a new genus of Rhodocrinidæ, named Diamenocrinus. The axial folding of the cup-plates of the type species, D. Jouani, suggests a discussion of this structure in the Camerata generally. The stem of this species appears to have been coiled at its distal end, and is compared by the author with the stem of Herpetocrinus, which is, however, coiled at the other end; at the distal end the stem of the latter is pentagonal, and this leads the author to a discussion of Messrs. Wachsmuth and Springer's law of stem orientation.

A. Rothpletz in the work previously cited (*op. cit.*, pp. 74, 75)

founds a new species of Hypocrinus, which is based on a curiously abnormal specimen.

C. Wachsmuth and **F. Springer.** "Description of two new genera and eight species of Camerate Crinoids, from the Niagara group." (*Amer. Geol.*, x. 135.)—In this paper the most novel morphological point is that a curious fossil, which had been previously regarded as the orals of Pisocrinus, is now shown to be the oral pyramid of Idiocrinus ventricosus. More detailed descriptions and figures of these species will be given in the great monograph of the North-American palæozoic crinoids upon which these authors have been so long engaged.

G. Boehm (*Zeit. deut. Geol. Gesell.* xliii. 741) adds another to the numerous teratological cases of crinoids described this year: this one is an interesting abnormal cup of Millericrinus mespiliformis.

F. A. Bather. "British Fossil Crinoids." Parts vi., vii., and viii. (*Ann. and Mag. Nat. Hist.* [6], ix. 189.) These papers are devoted to a detailed description of Mastigocrinus (n. gen.), and to a revision of the much-known and misunderstood genus Cyathocrinus; two new species of the latter from the Wenlock Limestone, of Dudley, are also fully described. An elaborate account of the anal tube of Mastigocrinus forms an important addition to crinoid morphology.

The same author also gives "Suggested terms in Crinoid Morphology" (*tom. cit.*, page 51) revising the nomenclature of the radials, brachials, and interradials of both cup and oral surface, and anals. An elaborate series of symbols is proposed, which may yet raise the study of crinoids into the circle of the exact sciences.

Though dealing almost entirely with recent forms, the palæontologist cannot overlook **A. Agassiz's** magnificently illustrated monograph on "Calamocrinus diomedæ: a new stalked crinoid." (*Mem. Mus. Comp. Zool.*, xvii., No. 2, 95 pp., 32 pls. 4to.) This is a new genus obtained from the deep seas of the West Indies, and is of interest from its affinities to some Jurassic forms, a point which Professor Agassiz has previously emphasised in a preliminary note. In addition, the memoir discusses the general structure of the stem of crinoids and the actinal plates of echinoderms.

Echinoidea.

C. Schlüter. "Die regulären Echiniden der norddeutschen Kreide. (*Abh. k. Preuss. Geol. Landesanst. Neue. Folge. Heft.* 5.)—This is probably the most important work on the echinoids issued during the year, and represents several years of close study of the Chalk species. The synonymy of the Chalk

Cidaridæ has long been in confusion, mainly due to the fact that no satisfactory subdivisions of the great genus Cidaris have as yet been established. Numerous efforts to do this have been made, notably by Pomel and Döderlein, but the divisions appear very artificial. Prof. Schlüter accepts and improves many of these, and is thus able to group the species so that more detailed comparisons can be made. The divisions, however, still appear of but little morphological value. Many of our English cidarids will have to be renamed to bring them into harmony with the comprehensive scheme here proposed.

Sven Lovén. "Echinologica." (*Bihang. K. Sven. Vet. Akad. Handl.* xviii., Afd. iv., No. 1, 73 pp., 12 pl.)—Prof. Lovén's writings are always welcome to the palæontologist, for his mastery of both recent and fossil forms, and the elaborate patience and care with which his work is executed. In the present paper the descriptions of the early post-pluteal stage of some echinoids are of great interest in connection with the study of some primitive genera. He also continues (pp. 47—52) his account of the peri-gnathic girdle of some fossil forms, such as Discoidea and Galerites, and describes with care the dental system of Clypeaster.

Three additions have been made to the literature of the Australian Echinoidea. **R. Tate** has issued a bibliography and revised list of the described echinoids of the Australian Eocene deposits. (*Trans. R. Soc. S. Austr.*, xiv., pt. 2 [Dec., 1891], 270. The fauna is one of great interest owing to the mingling together of genera which in Europe are restricted either to the Cretaceous or the Cainozoic. Prof. Tate describes 6 new species, of which one belongs to a genus (Salenia) most abundant in the Cretaceous, one to Cardiaster, which is characteristically of that formation, and one to Scutellina, which is as typical of the Eocene.

J. W. Gregory also describes a new echinoid from the West Indies. "On Archæopneustes abruptus, a new genus and species of echinoid, from the oceanic series in Barbados." (*Quart. Jour. Geol. Soc.*, xlviii. 163, pl. iv.)—This fossil is of interest as it throws light on the age of the latest bed of the famous oceanic series, and indicates the depth at which the highest member of that formation was formed. The test is thick, and the limestone, in which it is not uncommon, may have been laid down at a depth of from 100 to 300 fathoms. A representative of the genus (previously included in Palæopneustes) now lives in the seas of Barbados: the fossil species being extinct; the radiolarian beds are not later than the Pliocene. The new genus also necessitates alterations in the classification of the echinoids. The evidence yielded by the Echinoidea as to the physical geography of the

Atlantic basin has been dealt with in another paper by the same writer. "A comparison of the fossil echinoid faunas of Europe and America." (*Bull. Geol. Soc. America*, iii., p. 101.) —The successive faunas from the Carboniferous to the Pliocene of both sides of the Atlantic are compared : it is pointed out that in the Carboniferous the two faunas are absolutely distinct, whereas the next (Neocomian) is identical on both sides; from this a gradual divergence continues throughout the Cretaceous, culminating in the Eocene. Then in the Miocene the faunas are again almost identical; moreover many of the species common to the two West Indian and Mediterranean faunas are tropical, shallow-water forms, and had no free-swimming larval stage. They cannot therefore have crossed the present deep and cold abysses of the Atlantic, while the evidence is conclusive that they did not follow the north shores of the Atlantic, but migrated along a route past the Azores. The writer therefore concludes that there must have been a shallow-water connection across the Atlantic in Miocene times. The Pliocene echinoid faunas give further evidence as to the nature and variations in this shallow-water area.

J. Lambert. "Note sur le genre Echinocyamus." (*Bull. Soc. Géol. France*, xix. [1891], 1892, 749.)—In the effort to establish a rigid and accurate scientific nomenclature it occasionally becomes the sad duty of the systematist to remove his neighbour's landmarks. One of these disasters has now overtaken the genus (or rather the name) Echinocyamus : the species which has hitherto been taken as the type of that genus, we now learn is really the type of Fibularia, in which must be included the common Crag and living British forms. The name Echinocyamus survives for the round, less known group of globular, and non-septate species.

Bryozoa.

The present year has been marked by a great dearth of literature in this group. The series of important memoirs by **Dr. E. Pergens** has unfortunately been interrupted by failing eyesight, while there is no American contribution to compare with **Ulrich's** great monograph issued last year.

A. W. Waters has concluded his revision of the North Italian Bryozoa. In part ii. he has dealt with the Cyclostomata. (*Quart. Jour. Geol. Soc.*, xlviii. 153, pl. iii.)—The author, however, does not attempt to deal with the puzzling question of the classification of this group. The revision, however, is of great value, as a supplement to the monographs of Reuss and Manzoni. The application of section-cutting has yielded some interesting conclusions.

G. R. Vine. "Report of the Committee appointed for the completion of a report on the Cretaceous Polyzoa." (*Rep. Brit. Assoc.* [not yet published].)—Mr. Vine is to be congratulated on the termination of his series of reports on the Bryozoa. In the present he adds one or two genera, such as Clinopora, to the English fauna. He names, but does not describe, many new species. A tabulation of the distribution of the English Cretaceous species is the most useful part of the present report.

Brachiopoda.

The most important work on fossil Brachiopods that has appeared during 1892 is undoubtedly "An Introduction to the Study of Palaeozoic Brachiopoda," by **Jas. Hall** and **J. M. Clarke.** (*Palæont.*, New York, vol. viii.)—This, the first part, deals with the Inarticulata and with the Orthis and Strophomena groups of the Articulata. The work is designed to set before the student the present condition of our knowledge of the genera therein contained, with such discussions and illustrations as will serve most clearly to indicate what progress has been made in our knowledge of these organisms, and in what directions much still remains to be done. In the present state of knowledge it was thought best to avoid the use of family designations altogether; consequently the various genera and subgenera are grouped around certain well-known and typical genera, such as Lingula, Trimerella, Obolella, Discina and Orthis, Clitambonites, Strophomena, Leptæna, Chonetes, Productus, but are at the same time so arranged as to show as far as possible the connections between the different types of structure. Not only is a thorough "literary" revision made of each genus, but the internal structure is admirably described and clearly figured in the beautful plates. What is of still greater importance, the whole treatment is in the highest degree scientific, and, as a natural consequence, delightfully lucid. Like Beecher, the authors take as the feature of paramount importance in classification the character of the peduncle passage. They trace the various modifications of this in the genera of Inarticulata, in which process we have not space to follow them. The discussion of the general relations of the Articulata is reserved for the next volume.

C. E. Beecher continues his very interesting researches on the development of the Brachiopoda (see "Year-Book" for 1891, page 332). In part ii., "Classification of the Stages of Growth and Decline" (*Amer. Jour. Sci.*, xliv. 133), he applies to the Brachiopoda the useful though barbarous terminology of Hyatt. He shows how in the Brachiopoda, as in other groups of the

animal kingdom, the stages of individual history reproduce the history of the race, and, conversely, how there is in the history of a race a youth, a maturity, and an old age. Modern Articulate brachiopods differ from the Inarticulate in having no anus; in many palæozoic Articulata, however, a notch occurring in the beak of the dorsal valve suggests that they possessed an anal opening dorsal to the median line, as in the recent Crania. Considering the evolution of the Brachiopoda as a whole, the author regards them as retrogressive in the loss of the anal opening and eyes, progressive in the concentration of the posterior and expansion of the anterior elements, and in the limitation of the peduncle opening to one valve.

Another contribution on this subject from the American school comes from the pens of **N. H. Winchell** and **C. Schuchert**, and consists of a "Preliminary description of new Brachiopoda from the Trenton and Hudson River groups of Minnesota." (*Amer. Geol.*, ix. 284.)

A. Bittner, "Brachiopoden der Alpinen Trias." (*Nachtrag* I. *Abh. k. k. Geol. Reichs.*, xvii., Ht. ii. 40, pl. iv.)—This work forms a supplement to the important and extensive monograph which was issued by Bittner in the end of 1890. Many new species are described and some revisions of old determinations made.

Mollusca.

The Triassic Mollusca as the earliest of Neozoic faunas, continue to absorb much attention. **A. Bittner**, "Neue Arten aus der Trias von Balia in Kleinasien" (*Jahrb. k. k. Geol. Reich.*, xlii., Ht. i. 77, pls. iv.—v.), describes a small series of mollusca from Asia Minor. **Tausch**, "Ueber die Bivalvengattung Conchodus und Conchodus Schwageri aus der obersten Trias der Nordalpen" (*Abh. k. k. Geol. Reich.*, xvii., Ht. i. 8, pl. 3), re-emends and revises one of the most typical of the genera of this period. **Dr. Ernst Koken**, "Ueber die Gasteropoden der rothen Schlernschichten nebst Bemerkungen über Verbreitung und Herkunft einiger triasischer Gattungen" (*Neues Jahrb.*, 1892, Bd. ii., Ht. i. 25), continues his studies of the gasteropoda, which in his previous publications he followed as far as the top of the palæozoic.

B. B. Woodward, "On the mode of growth and the structure of the shell in Velates conoideus, Lamk., and other Neritidæ" (*Proc. Zool. Soc.*, 1892, 528, pls. xxxi.—xxxii.), describes the mode of the growth of the shell of Velates as quite unique. A thick mass of callus is deposited on one side of the floor of the shell. As growth proceeds the callus is hollowed out by

internal absorption, and thus space is provided for the enlarging mollusc.

A. Pavlow and **G. W. Lamplugh.** ("Argiles de Speeton et leurs équivalents" [*Bull. Soc. Imp. Nat.*, Moscow, Nos. 3 and 4 (1891), 1892, pp. 212, pls. 11].)—Though the main argument of this paper is stratigraphical, it forms a most important addition to the knowledge of the Upper Jurassic and Lower Cretaceous Cephalopods, especially the belemnites; these are described on pp. 34–96. A reclassification of the genus is given; it is divided into six groups, for most of which the names of Neumayr have been accepted. The history of the evolution of the genus is given on pp. 92–96, and this includes a table showing the course of development in geological time. The ammonites of the faunas discussed are less important. (See page 276.)

The value of the Cephalopoda to the stratigraphical geologist is also shown by a paper by **S. S. Buckman** on "The reported occurrence of Ammonites jurensis in the Northampton Sands." (*Geol. Mag.* [3], ix. 258.)—The author maintains that this bed is really on the horizon of the Opalinum, and not the Jurensis zone, as has previously been maintained. To facilitate subsequent discussion he prints brief summaries of the diagnoses of the species allied to A. jurensis.

A phylogenetic contribution from the same author is a note entitled "On the morphology of Stephanoceras zigzag." (*Quart. Jour. Geol. Soc.*, xlviii. 447, pls. xiii.—xiv.)—He gives a genealogy of the whole *zigzag* series; this he regards as a branch from the coronate radical, advancing to the spinous stage at a later date than the Humphresianus series, to which it is the morphological equivalent. Both give rise to costate forms.

Among other general systematic papers on the Mollusca may be mentioned **Miss J. Donald's** "Notes on some new and little-known species of Carboniferous Murchisonia" (*Quart. Jour. Geol. Soc.*, xlviii. 562), and especially the fourth fascicule of **M. Cossmann's** "Catalogue illustré des Coquilles fossiles de l'Éocène des environs de Paris" (Paris, pp. 166, pl. 3), and **W. H. Hudleston's** "Monograph of the Jurassic Gastropoda" (*Palæontogr. Soc.*, xlvi. 273). In **E. O. Ulrich's** "New Lamellibranchiata" (*Amer. Geol.*, x. 96, pl. vii.) a new genus (Cleionychia) is founded for Hall's Ambonychia lamellosa. But these papers are either of interest to systematists only, or in the case of those which are only parts, notice may well be postponed till the completion of the monographs.

J. F. Blake. "The Evolution and Classification of the Cephalo-

poda: an account of recent advances." (*Proc. Geol. Assoc.*, xii. 275.)—In this paper, which formed the Presidential Address delivered to the Geologists' Association, Mr. Blake gives a summary of recent classifications, reserving his own conclusions till later. He sketches the gradual breaking up of the old genus Ammonites from the time when, in 1865, Suess separated Arcestes, Phylloceras, and a few other lower Mesozoic forms. Hyatt, in 1867, and Waagen, with his scheme of "mutations" (first called "developmental series"), followed the example set by Suess; a powerful stimulus was also afforded by the third part of Neumayr's Jura-studien; Würtemberger's phylogenetic studies (Darwinistische Schriften, No. 5, 1880), with his illustration of Neumayr's suggestions of adult atavism by the seven stages of the Lias Planulati, helped in the same direction, and this line of work has recently culminated in Hyatt's "Genesis of the Arietidæ." An interesting summary of the literature, with tables of the most recent classifications, including those of Zittell, Bather, and Steinmann, are given; the author regards that of the last author as the best. The paper will also be valuable to English students, from its brief and neat definitions of many of Hyatt's terms; for until the reader has mastered the meaning of the terms paracme, nepionic, epacme, ephebolic, and hosts more of such, the writings of the most brilliant existing school of invertebrate palæontologists must remain so much unintelligible jargon. [These terms are explained, emended, and re-defined in a paper by **S. S. Buckman** and **F. A. Bather**, "The Terms of Auxology" (*Zool. Anzeiger*, Nov. 14 and 28, 1892, pp. 420 and 434.)]

C. R. Keyes discusses the nomenclature and classification of the Platyceras group of Gastropods. The name Platyceras is discarded and the three genera Capulus, Igoceras, and Orthonychia recognised. (*Amer. Geologist*, x. 273.)

S. S. Buckman in his monograph on the Inferior Oolite Ammonites has some considerations on the evolution of the Sonniniae. (*Palæontogr. Soc.*, xlvi. 313; pls. 17—76.)

PALÆOBOTANY.

By THOMAS HICK, B.A., B.Sc.

The year has not been marked by any startling discoveries in Palæobotany, but good work has been done in clearing up long-standing difficulties, revising the descriptions and determinations

of previous workers, and bringing the fossilised fragments of plants into their proper relations one with another. The anatomy and histology of Carboniferous plants have again occupied a large share of attention, and it is here perhaps that the progress of the year has been most marked. Fortunately progress in these matters is not only good in itself, but leads to progress in our knowledge of the morphology and affinities of the plants concerned, and so results in greater coherence and consistency, and often in the elimination of superfluous genera.

Flora of the Carboniferous period.

In a new work by **Grand'Eury** it is shown that the various strata of the coal basin of Gard may be grouped according to their floras into three very distinct stages, separated by thick sterile deposits—viz., a lower, or stage of Bessères; a middle, or stage of Grand'Combe; and an upper, or stage of Champclauson. In the first of these he distinguishes three sub-stages and classes apart, certain strata lying quite at the base of the series, as well as the sterile deposits which crown the whole. He thus arranges the entire series of beds in nine successive divisions—obviously of unequal importance—six of which are productive and three are sterile.

Quite at the base of the series are certain brecciaform deposits, which are characterised by a special flora, comprising Pecopteris arborescens, Pec. gracillima, Pec. abbreviata, Dictyopteris nevropteroides, Cordaites borassifolius, Lesleya angusta, along with Alethopteris irregularis, Aleth. crenulata (not Brongmart's sp.), and a new type, Cebenna pterophylloides. Above these is a group of carbonaceous beds, including those of Pradel, Feljas, and Pigère, whose flora is distinguished from the next higher stage of Bessères by the absence of Pecopteris lamuriana, Pec. polymorpha, and Pec. pteroides.

The stage of Bessères is divided into three sub-stages, of which the lower contains Pecopteris lamuriana, Pec. abbreviata, Nevropteris flexnosa, Sphenophyllum truncatum; the middle, Sphenopteris chærophylloides, Sph. quadridactylites, Pecopteris lamuriana, Pec. discreta, Pec. ellipticifolia, Pec. erosa, Sigillaria tesselata, Sig. elliptica, Sig. Defrancei; and the upper, Pecopteris cyathea n. sp., Pec. unita n. sp., Alethopteris Grandini n. sp., Nevropteris cordata n. sp., with Odontopteris Reichiana, which increases in abundance, while other species, among them Pecopteris lamuriana, disappear.

The stage of Grand'Combe is characterised by a flora consisting of a mixture of lower and upper species, and the absence

of both the oldest and the most recent forms. In it are found Pecopteris cyathea, Pec. unita, Pec. Platoni, Alethopteris Grandini, Al. aquilina, Odontopteris Reichiana, Od. obtusa Weiss, Sphenophyllum Schlotheimi, Sphen. oblongifolium, Sigillaria Candollei, Sig. lepidodendrifolia, with numerous examples of Cordaites borassifolius, Cord. Plingulatus, and Poacordaites linearis.

Finally the stage of Champclauson contains a flora sharply characterised by a series of superior species, such as Pecopteris cyathea, Pec. hemitelioides, Callipteridium gigas, Dictyopteris Schützei, Tæniopteris jejunata, Sphenophyllum longifolium, Sigillaria Brardi, and Sig. spinulosa, as well as by the disappearance of ribbed Sigillariæ. (**Grand'Eury**: *La Géologie et la Paléontologie du Bassin Houiller du Gard.*)

Pila bibractensis—an alga from the Permian of Autun.

Messrs. **C. Eg. Bertrand** and **B. Renault** have issued an elaborate memoir on an alga found in the Boghead of Autun, to which they give the name Pila bibractensis. It is described as a gelatinous alga, with an ellipsoidal, multicellular thallus. The thalli occur isolated or grouped together in beds of variable thickness. They are not mineralised, nor has the minute structure been preserved by impregnated calcite, but by a special mode of preservation of the gelatinous matter of the cell walls, and the partial coloration of the thallus by brown substances derived from the alteration of the carbonised jelly.

Thalli of moderate dimensions measure 0·189 mm. to 0·225 mm. in length, 0·136 mm. to 0·160 mm. in breadth, and 0·096 mm. to 0·115 mm. in vertical height. Numerous sections made in various planes parallel to the three axes enable the authors to make out that the thallus is composed of a large number of polyhedral cells. The external elements are a little larger than the central ones, which are isodiametric, and frequently exhibit the beginning of dissociation. The protoplasm appears homogeneous, and, save the nucleus, is destitute of any organised structures, such as chromatophores, starch grains, vacuoles, etc. Further, the authors have not been able to find any superficial hairs like those of Coleochæte, nor heterocysts like those of Nostochaceæ, nor vibratile cilia like those of Volvocineæ, nor have any traces been found of sporangia, hormogonia, sexual organs, or embryos. By the progressive dissociation of the thalli fragmentation is brought about.

The affinities of the alga are very doubtful. For reasons shown it can scarcely be referred to the Florideæ, Coleochæteæ, Fucaceæ, or Volvocineæ, and ought probably to go among the

asexual Thallophytes. There are few of these, however, which can be compared with Pila, though there are some analogies between it and the Leuconostoc mesenteroides of Van Tieghem and Gomphosphæria aurantiaca. The resemblances, however, are merely superficial, and not sufficient to enable the authors to say that Pila belongs to either the Chroococcaceæ or the Pleurococcaceæ. On the other hand it has no character which would authorise them to regard it as higher than these groups. For the present it may be considered as a low form of gelatinous Thallophyte. (**Bertrand** and **Renault**: *Bull. de la Soc. d'Hist. Nat. d'Autun.* Tome Cinquième, 1892.)

The Calamarieæ.

In his description of the flora of the coal-basin of Gard, **Grand'Eury** records some remarkable observations he has made on the Calamodendreæ and Sigillariæ found in the quarries of Richard and Champclauson. These lead him to the conclusion that the Calamarieæ of the upper coal measures form two sharply-separated groups: (1) that of Calamites cannæformis with Arthropitys and Asterophyllites, and (2) that of Stylocalamites with Calamodendron.

As regards the first group, he finds that in Gard, Calamites cannæformis is almost always associated with the woody stems of Arthropitys, carrying verticillate branches of Asterophyllites, with regular distichous branchlets. Sometimes the woody stems are accompanied by herbaceous ones, which apparently belong to the same individuals. The specimens which he has named, Calamophyllites (Calamitina of Weiss), are the external surfaces of these stems with the leaves attached, and he refers to them different types of fructification. Thus Asterophyllites equisetiformis, he says, had slightly thickened uni-nerved leaves, with Volkmannia sporangiferous spikes, while Asterophyllites densifolius had more coriaceous and lignified leaves, with spikes of Macrostachya. Calamites pachyderma he regards as the submerged portion of the stems of these last plants or the parts plunged in the mud.

As to the second group, he regards the species known as Calamites Suckowi and Cal. Cisti, from the upper coal measures, as the herbaceous stems of Calamodendron, and to them he refers certain leafy branchlets and spikes under the names of Calamocladus and Calamostachys. These branchlets arise singly and irregularly at the nodes, and carry flattened multi-nerved leaves, which are often slightly sheathed at the base. With Calamocladus parallelinervis n. sp. are associated small spikes, consisting of an axis with a number of stalked peltate sporangiophores,

each carrying four sporangia but destitute of sterile bracts. Other spikes, however, have short, almost filiform, sterile bracts, alternating with the fertile whorls, while another species, Calamostachys tenuissima, destitute of sterile bracts, recalls Equisetum by the greater number of sporangia attached to each sporangiophore. As dissimilar spikes are sometimes found in relation with leafy branches which are apparently identical, it is possible that there is more differentiation in the reproductive structures than in the vegetative organs. As these fragments are obviously found in or near the spot where they lived, and no seeds of any kind or other reproductive organs besides the spikes, the author concludes that Calamodendron and Arthropitys are Cryptogams belonging to the Calamarieæ.

Near these plants he places a new type named Autophyllites furcatus. This consists of small articulated stems with Calamitoid nodes, and large, linear, coriaceous leaves united at the base and bifurcated at an acute angle. Small spikes arise in the anils of these leaves, which carry sporangiophores but no sterile bracts. These stems have simple leaves at the base, and appear to be attached to rhizomes with still shorter leaves. Sphenophyllum, some species of which have been wrongly confounded with Asterophyllites, he regards as constituting a distinct family, without well-marked affinities with other Carboniferous Cryptogams. (**Grand'Eury**: *La Géologie et la Paléontologie du Bassin Houiller du Gard.*)

Development of Sigillaria from Stigmaria.

Perhaps the most striking part of **Grand'Eury's** account of the coal basin of Gard is that which furnishes some idea of the development of Sigillaria from Stigmaria. Stigmariæ he regards as rhizomes which grew on or in mud, or floated in water, and were capable of growing indefinitely without producing an aërial stem. But rhizomes were met with which produced large bulbs, as the first stage of the trunks of Sigillariæ, the bulbs presenting four swellings, which by elongation give rise to the well-known cruciate form of the base of Sigillaria. At first neither the stem nor the root-like branches carry appendages, the latter taking the form of Stigmariopsis, while the former, often swollen into the shape of a bottle, takes that of Syringodendron of the type of Syr. alternans. Thus, while according to this view Syringodendron represents the basal part of the trunk of Sigillaria, that, namely, which is immersed in water or mud, and is deprived of leaves, Stigmariopsis is the proximal part of Stigmarian axes.

As no traces of seeds have been found along with Sigillaria,

but only spikes with macrospores, it is held that the Sigillariæ of the upper coal measures, as well as those of the middle, should be classed definitely as Cryptogams. (**Grand'Eury**: *La Géologie et la Paléontologie du Bassin Houiller du Gard.*)

Sir J. W. Dawson, referring to these results, points out that Stigmariæ are not the roots of Sigillariæ alone, and that they grew in the soil or in the upper layers of peaty deposits which have since been changed into coal. In his experience the bulb-like formation is an exceptional phenomenon, and he thinks the appearance compared to Syringodendron at the base of Sigillaria has really no connection with the genus Syringodendron as described by Sternberg and Brongniart. On the other hand the term Stigmariopsis, he says, might be fairly applied to those Stigmariæ which have a wrinkled surface and somewhat irregular areoles. He adds that he is not aware of any instance of a stem of Sigillaria springing as a bud from a branch of Stigmaria or its termination, as is described by Grand'Eury. (*Nat. Sci.*, i. 211.)

Professor Williamson, in reference to the same subject, says that Grand'Eury's statement that Stigmariæ are rhizomes is altogether inapplicable to anything that we discover in Great Britain. He objects to Grand'Eury calling fossils by the name of Stigmaria which are very different from those which are so called in this country, and which he maintains are the true Stigmaria ficoides Brongt. In none of these do we discover, he says, the faintest trace of any bud or bulb, nor yet of any indication of a point to which such a growth could have been attached. (*Nat. Sci.*, i. 214.)

The morphological nature of Stigmaria ficoides Brongt.

The publication of Grand'Eury's work has led to a renewal of the discussion of the morphological nature of Stigmaria ficoides, and especially as to whether it is a root or a rhizome.

T. Hick recapitulates the external and internal characters of Stigmaria and its appendages, that must be taken into account in arriving at a definite opinion on the subject. Among these he refers to the quincuncial arrangement of the appendages, their disarticulation, their diminution in size towards the growing point of the axis where they are more closely approximated, their incurving over the same after the manner of the leaves of a bud, and their subsequent assumption of a position at right angles to the axis by epinastic growth. In these respects Stigmaria ficoides differs from all known roots. On the other hand every one of these characters is in harmony with the hypothesis that Stigmaria

is a rhizome, and on that hypothesis they are all capable of a simple explanation.

The internal anatomy of the axis points to the same conclusion. In young specimens there is a well-developed parenchymatous pith surrounded by a ring of collateral vascular bundles, but no trace of the radial centripetally-developed bundles enclosed in a pericycle and endodermis so generally met with in roots. In older axes there is the same absence of all root characteristics, and though secondary growth in thickness is a normal feature, it does not originate in the way which is characteristic of roots, but rather in that which prevails in stems.

The anatomy of the appendages has been held to have a strong resemblance to that of the roots of Ophioglossum, Lycopodium, Selaginella, and Isoetes, especially in the possession of a single monarch vascular bundle, and on this account they have been regarded as rootlets. Hick suggests that this bundle, instead of being monarch, may be collateral, as some high authorities maintain, and points out that its development, as described by Williamson, differs *in toto* from that of a true monarch bundle. On these grounds he holds that the evidence of the vascular bundles in favour of the view that the appendages are rootlets is considerably weakened if not destroyed. Without insisting upon this, however, he leaves the nature of the appendages as indicated by structure for the present an open question.

Against the inferences drawn from the above facts it is sometimes urged that the laws of plant morphology were different in Carboniferous times from what they are to-day, and that the various members of plants, *e.g.*, roots and stems, were not then so sharply differentiated. Anticipating such objections, Hick contends that so wide a generalisation as the first should be established on indisputable evidence before it is applied deductively in this way. As to the second, he thinks a difference of roots and stems in the higher types of plants, even in Carboniferous times, may be justly assumed until positive evidence to the contrary is forthcoming.

In conclusion, the structure of Stigmaria ficoides is held to show that its organisation approaches closely to that of a stem and has nothing in common with that of a root. As, moreover, it is known from observation that it was not aërial, the conclusion is indicated that it is a rhizome. (*Nat. Sci.*, i. 360.)

To the above paper **Prof. Williamson** has written a reply. At the outset he states the opinion that in dealing with Palæozoic plants we must not appeal to existing types "for illustrations and explanations of structures no longer existing," and "still less must we turn to what we find in Angiosperms." He quotes the

definitions of a rhizome given by Sachs, Maout and Decaisne, and Henfrey, and asks in what single point British Stigmariæ agree with any one of these definitions.

As to the external characters of Stigmaria, he contends that although no root is now to be found in which the rootlets are arranged in quincuncial order, it does not follow that such an arrangement could not formerly have occurred, and thinks it very far from the truth to say that the external characters of Stigmaria are all in harmony with the hypothesis that it is a rhizome. He recapitulates the main points in the definitions given of a rhizome, and refers to the specimen of Stigmaria in the Owens College Museum and described in his monograph of Stigmaria ficoides, in order to show that in the absence of terminal buds, lateral branches, and leaves, Stigmaria ficoides fails to satisfy the requirements of the definitions and cannot therefore be a rhizome. Moreover, as Stigmaria has only one kind of appendage, he asks what can be made of them but rootlets. As to the vascular bundles of the appendages, he insists that they are monarch bundles, developed "from a monarch tracheid side by side with a phloem element," and quotes the authority of Van Tieghem in support of his contention that the appendages are roots. (*Nat. Sci.*, i. 365.)

In a very brief rejoinder **T. Hick** maintains that the specimen in the Manchester Museum at the Owens College is not inconsistent with the view that Stigmaria is a rhizome, and refers to the "Fossil Botany" of Count Solms as supporting that view. As to the vascular bundles of the appendages, he quotes Count Solms, who describes them as collateral, and points out that apart from the mode of origin, monarch bundles are scarcely if at all distinguishable from collateral ones. This being so, the evidence of origin is crucial, and is certainly against the contention that the bundles of the appendages are monarch. (*Nat. Sci.*, i. 370.)

The sporangiferous spike of Sphenophyllum cuneifolium.

In a communication to the Academy of Sciences **Zeiller** has dealt with the constitution of the spore-bearing spike of Sphenophyllum cuneifolium. In his work on the "Flore Fossile du Bassin Houiller de Valenciennes" he described and figured some of these spikes, but the publication of Williamson's memoir on "Bowmanites Dawsoni" led him to a fresh examination of his specimens. From one of these he has obtained a spike much better preserved than those previously studied by him, and has besides been able to examine some excellent specimens from the Belgian coalfield.

As a result he concludes that the spikes of Sphenophyllum cuneifolium were at all points identical with the spike described by Williamson, first as Volkmannia Dawsoni, and more recently as Bowmanites Dawsoni. This identity applies quite as much to the structure of the spike as to the dimensions of the various parts. The sporangia are multiseriate and have pedicels which are recurved at the extremity towards the axis of the spike, and form a sort of raphe or annulus along one portion of the contour of the sporangium. Some sporangia are open, divided in some way into two valves by a longitudinal slit, and the author suggests that perhaps the cells of the annulus assist in the dehiscence. Except as regards size, the appearance of the sporangia thus attached has some resemblance to that of the sporocarp of Marsilea, and this Zeiller considers not to be purely superficial. The pedicels he regards as representing the ventral lobes of the bracts, and analogous to the fertile lobe of the fronds of Ophioglosseæ or to those of the Marsileaceæ, only they carry at their extremity not a series of sporangia as in the first group, or several sori as in the second, but a single sporangium with a wall formed of a single layer of cells.

He concludes from this structure of the spike of Sphenophyllum cuneifolium that if Sphenophyllum recalls the Lycopodineæ by the structure of its axis, it is removed far from them by the special structure of the fruit apparatus, which tends to bring them nearer to the Rhizocarpeæ. Hence he thinks they should be considered as a distinct class of Cryptogams.

Finally he suggests that the genus Bowmanites should henceforth disappear, B. cambrensis and B. germanicus being without doubt, as well as B. Dawsoni, spikes of Sphenophyllum, and pertaining possibly, like it, to Sphen. cuneifolium. (*Comptes Rendus*, cxv. 141.)

New fossil plant from the Lower Coal Measures of Halifax.

In the *Journal of the Linnæan Society* **T. Hick** describes a fragment of what appears to be a new fossil plant from the Lower Coal Measures of Halifax. The external appearance of the fragment bears some resemblance to that of Stigmaria, as its surface carries a series of markings which have a quincuncial arrangement. When found the specimen was about 1·1 decimetre in length, with a diameter of about 5 centimetres, and though generally cylindrical in shape was slightly compressed. The centre of the transverse section is occupied by a true pith $2\frac{1}{2}$ millimetres in diameter, surrounded by a ring of collateral vascular bundles, made up of scalariform tissue and separated by medullary rays. The bundle

ring has a diameter of 5 millimetres, and at certain points small bundles are leaving it to pass off to lateral appendages. The ring of bundles is surrounded by a narrow layer of tissue, which is probably the pericycle, and outside this is a relatively very thick mass of tissues—termed enveloping tissues by the author—whose structure is of a remarkable character. There are no leaf-cushions at the outer periphery, but at two points what appear to be two rootlets project from one side.

Near the outer edge of the enveloping tissues there runs an undulated line roughly parallel to it, separating an outer narrow zone of parenchymatous tissue—believed to be the true cortex—from the thick inner tissues which are distinguished as the "radicular tissues." In the latter, which are for the most part parenchymatous, are numerous root-like structures, each composed of a collateral vascular bundle surrounded by a zone of parenchyma. Some of these structures are organically connected on every side with the parenchyma in which they lie, while others are separated from it by a narrow fissure, which save at one point completely surrounds them. Where this incomplete separation has occurred the periphery of the root-like structure is characterised by the presence of a sort of periderm. In other parts of the "radicular tissues" bands of periderm-like tissue are met with, which divide the parenchyma into irregularly-shaped masses, which may or may not contain a small vascular bundle in the centre.

The true cortex is parenchymatous throughout, but the elements are not uniform in their characters at all points.

Though not entirely free from difficulties, the author thinks the best explanation of this part of the fossil to be that the "radicular tissues" have been intercalated between the pericycle and the true cortex by secondary developments.

The histology of the various tissues of the fossil is dealt with at great length, and then the author proceeds to consider its probable morphological nature. On the anatomical evidence which it affords the conclusion is reached that it is a stem structure rather than a root, and that the probabilities are in favour of the view that it is a rhizome.

Of the systematic position of the plant the data at command are too meagre to warrant even an approximative conclusion. On the assumption that it is a Vascular Cryptogam, the author institutes a comparison between its anatomical structure and that of a number of typical forms of that group, but finds it impossible to decide to which family it must be referred. The arrangement and structure of the vascular bundles seem to remove it from the

Lycopodinæ, whilst among the Filicinæ the only comparable forms are Osmunda, Botrychium, and Ophioglossum, where the vascular bundles are also collateral, and arranged in a circle. As to the root-like structures of the enveloping tissues, they are to some extent comparable to the roots found in the cortex of some Lycopodiaceous and Marattiaceous plants, so that this feature is equally consistent with affinities with the Filicinæ and Lycopodinæ.

As a provisional designation for the fossil the author has named it Xenophyton radiculosum. (*Journal of the Linnæan Society*, Botany, xxix. 86.)

Trizygia, Sphenophyllum, and Asterophyllites.

The discovery by **M. de Bosniaski**, in the Coal Measures of Mount Pisano, of fossils which he refers to Royle's genus, Trizygia, has induced M. Zeiller to re-examine the claims of that genus to be regarded as autonomous. In 1850 MacClelland and Unger placed Trizygia speciosa of Royle in the genus Sphenophyllum, and in 1876 O. Feistmantel accepted this view. In 1879 Feistmantel changed his opinion, and gave reasons for separating the two genera, pointing out, among other details, that in Sphenophyllum the leaves are of uniform size and equidistantly placed in each verticil, while in Trizygia the leaves are unequal and grouped at each node in three distinct pairs, the anterior pair being formed of shorter leaves than the lateral ones.

Zeiller now shows that the inequality in the size of the leaves and their grouping into three pairs are phenomena that are met with in Sphenophyllum, as *e.g.* in Sphenophyllum oblongatum and Sphen. filiculme of the Upper Coal Measures and the Permian. He admits that this might be a reason for referring these species to Trizygia rather than the reverse, but remarks that to justify such a course the characters in question should be constant. This appears to be the case in such fragments of Sphen. filiculme as have hitherto been met with, but it certainly does not hold with regard to Sphen. oblongifolium. Hence he thinks that where present these characters are probably the consequence of external conditions, and being of no generic value, the Indian species of Trizygia, on which the genus was based, should be referred to Sphenophyllum, as was done by MacClelland and Unger.

Coming to the specimens of Mount Pisano, which De Bosniaski names Trizygia speciosa Royle and Trizygia pteroides n. sp., **Zeiller** finds the former closely similar to the Indian species, but as the form, size, nervation, and arrangement of the leaves—

judging from Bosniaski's figure of an isolated verticil—agree exactly with those of Sphenophyllum verticillatum, he asks whether it should not be referred to that species rather than to Sphen. speciosum Royle. In Trizygia pteroides the leaves of each verticil have an arrangement which has not yet been met with in Sphenophyllum, and which would warrant the creation of a third genus, if such characters were to be relied on. In place of the six leaves joined in three pairs as above described, it presents two long lateral leaves diametrically opposite to one another, and four leaves shorter by one half placed anteriorly. This may be a new species, but the form and nervation of the leaves seem to be very little different from those of Sphenophyllum verticilatum.

In discussing the anatomy of Trizygia the author has some useful remarks on the relations of Asterophyllites and Sphenophyllum, which are often confounded with one another. Reminding the reader that the latter may have leaves so deeply divided that the segments become linear, he maintains that this does not make it an Asterophyllites, the two genera remaining absolutely distinct by their mode of branching, the anatomical structure of their stems, the constitution of their fruit spikes, and other characters. Thus, he says, Sphenophyllum myriophyllum Crépin has strongly decompound leaves, which may easily be confounded with those of Asterophyllites, although a careful examination seldom fails to bring to light the characteristic bifurcations. In the majority of species, however, leaves so much divided are extremely rare, and in some cases where the branches have simple leaves they carry branchlets having the normal cuneiform lamina. This is the explanation, in his opinion, of the specimens of Sphenophyllum cuneifolium described by A. C. Seward, and that of Sphen. oblongifolium described by Renault. (**Zeiller**, *Bulletin de la Soc. Géol. de France* [3], xix. 673.)

PHYSICAL GEOLOGY AND GEOGRAPHY.

By Professor H. G. SEELEY, F.R.S.

RECENT EXPLORATION.

The Pamir.

Sir George Littledale approached the Pamirs on the north by the Alai plateau, which stretches east and west as far as the eye could reach, and is ten or twelve miles wide. The land is treeless, with an elevation of about 10,800 feet. The Pamir River

is 100 yards wide, and flows through Victoria Lake on the Great Pamir. The lake is 13,980 feet high, and on the 27th of June was half covered with the last winter's ice, one or two feet thick in places. On the south the mountain dividing the Pamir from Wakhan is clothed with glaciers and snow peaks. Remains of old moraines extend down the river. The winds were violent, with heavy snowstorms on the Great Pamir, 14,800 feet high, and the land was remarkably barren. The Little Pamir also has a lake with low shelving banks in a flat valley, which is surrounded by high snowy peaks. The surface of the Pamirs is estimated at 280 miles in length by 150 miles in breadth, with an average height of 12,000 feet. It is a land with nine months' winter and three months' cold weather. (*Proc. Roy. Geog. Soc.*, xxv. 1.)

Insular condition of Greenland.

There has for a long time been a suspicion that Greenland is an island. And this conclusion has been almost demonstrated by the arctic exploration accomplished by **Lieut. R. E. Peary**, U.S.N., in the summer of 1892, by overland sledge travelling with Esquimaux dogs. Approaching the country from the west coast, the most northern point made was Cape Washington, about 83° 30′ N. 39° W. The land extended first to the N.N.E. and then to the S.E. On the 4th of July Independence Bay was reached, into which the great Academy glacier flows from the south. Independence Bay is about a third of the way from Cape Washington towards the land reported on the east coast of Greenland in 78° 30′ N. 19° W., which is distant from Cape Washington about 350 geographical miles. All the northern fiords have glaciers flowing into them, and the continental ice-cap of Greenland terminates at the Victoria Inlet on the west coast in about latitude 83° 30′ N. In the far north the land was red and brown in colour, and almost free from snow; covered with angular stones of all sizes, and glacial débris. In this region flowers, insects, and musk oxen were abundant, while traces were found of foxes, hares, ptarmigan, and possibly wolves. (*Proc. Roy. Geog. Soc.*, xiv. 697.)

LAKES.

The new Lake in the Colorado desert.

There are many depressions in the basin of California, which lies between the Wasatch Mountains on the east and the Sierra Nevada on the west. Over this area are dotted small lakes filled with saturated brine; and there are surfaces levelled by evaporation, which are dried-up lake-beds, termed "sinks." The

drainage of the region is carried away by the Colorado River, running south by Yuma into the head of the Gulf of California. From near Yuma a stream, known as the New River, has pushed its way westward, owing to the silting up of the Colorado, as far as the sink of San Felipe. Here the waters expanded, and the sink became Salton Lake. This is situate in Coahilla Valley, 300 feet below the level of the Gulf of California. Death Valley, further north, prolongs the depression, and is 225 feet below the level of the sea; so that it appears as though both valleys were portions of a northern extension of the Californian Gulf, dried up by upheaval and evaporation. The vegetation of this region is a few species of Yucca, Cactus, and Palm. The temperature remains for weeks between 100° and 125° F., and 145° at midday; so that when the Salton Lake was first formed its temperature was above 100° F. The rainfall rarely exceeds two or three inches a year. The evaporation is enormous, and the future of the lake depends upon successive seasons of high water in the Colorado. (**J. W. Redway**, *Proc. Roy. Geog. Soc.*, xiv. 309.)

The rise and fall of Lake Taganyika.

The lake varies 30 feet in level, owing to its outlet becoming blocked. Cameron has stated that the river Lukuga, which drains the lake, becomes blocked by vegetation. At the southern end of the lake are promontories with valleys between them, exposed by the recent fall in level of the water. One of these valleys is barred by an embankment about 300 feet long and about 20 feet above the level of the valley. This ridge appears to be like that described by Cameron as a "grass-grown sandbank" at the entrance of the Lukuga, through which there was a channel 300 to 400 yards wide. Each year towards the end of the rains the lake rises about two feet, and then gradually falls. The vegetation from the lake becomes jammed into the outlet of the Lukuga, and this closing of the channel by a porous stopper dams back the waters for many years till it gives way. (**A. Carson**, *Quart. Jour. Geol. Soc.*, xlviii. 401.)

CHANGES OF LEVEL OF LAND.

The relation of Deposition to Subsidence in the Gulf of Mexico.

It has been urged that mountains are high because they are light, and that sea-bottoms are low because they are heavy. The balance in level is considered to vary when denuded regions become elevated, and areas of deposition continue to

subside because they are being loaded with sediment. This presumed balance has been named by Dutton, Isostasy.

W. J. McGee urges that this theory of subsidence is supported by much direct evidence from observed facts. Thus a large class of earthquakes affects regions of rapid deposition, and after the trembling the land takes a lower level. It is affirmed that the Charlestown earthquake of 1886 depressed the Atlantic coast plain of the United States, and that similar relations of earthquakes to subsidence are indicated in the Lisbon, Kach, Cachar earthquakes, and other catastrophes.

Most of the areas in which deposition is going on, which are removed from both volcanic areas and areas affected by ancient glaciation, are characterised by rapid encroachment of the waters. The south-eastern shore of the North Sea is cited as an example. In that area the Rhine, Maas, Scheldt, Weser, and Elbe deposit their sediment, and it has been sinking since the beginning of authentic history. The measured rate of depression of the Dutch coast varies between ·09 and ·75 metre in a century, and since 1732 the depression has been almost exactly a quarter of a metre in a century. The tract about New York Bay is estimated to have sunk two feet in a century. The author regards the sand dunes of Holland and the Keys of America as indications of depression; but the most remarkable evidence is found on the shores of the Gulf of Mexico.

The area undergoing denudation—which empties, by means of rivers, into the Gulf of Mexico—is given as 1,804,737 square miles, and after comparing this area with the other chief areas of deposition by rivers, the author concludes that their subsidence is proportional to the activity of the rivers in bringing down sediment.

The evidence of depression in the Gulf of Mexico consists in the disappearance of many islands along the coast of Louisiana; secondly, the coasts are skirted, with one or two exceptions, by Keys, from the Rio Grande to the Strait of Florida. There are also buried forests, aboriginal shell mounds nearly or quite submerged, and salt water overflowing many existing pine forests.

From these indications it is inferred that the sinking of the land on the coast of the Mexican Gulf is nearly as rapid as on the coast of New Jersey. The maximum area of deposition is less than 300,000 square miles, and the area of appreciable deposit is probably 100,000 square miles. So that, if the valley of the Mississippi is being lowered by sub-aërial denudation one foot in 6,000 years, the deposit is accumulating in the Gulf of

Mexico at the rate of one foot in 333 years. Hence the author contends that the land and sea are in a state of hydrostatic equilibrium, so adjusted that any transfer of the load produces a deformation of the earth. (*Amer. Jour. Sci.* [3], xliv. 177.)

The ancient physical geography of Trinidad.

From a consideration of the Naparima rocks of Trinidad **R. J. L. Guppy** concludes that there was a sea during the Cretaceous and Eocene periods, probably a thousand fathoms deep, in the region now occupied by those rocks in Trinidad; and that this sea extended northward for about 20 miles. At that time the northern mountains of Trinidad are supposed to have formed a continuous range with the chain on the coast of Venezuela, termed the Parian range, which helps to enclose the Gulf of Paria. That range formed the southern boundary of the Caribbean continent before subsidence made the gap which separates Trinidad from Venezuela. There may have been volcanic action on the north side of the Parian range, since a little volcanic dust is found in the Trinidad rocks. The Orinoco is believed to have been then in existence, but to have brought no appreciable amount of sediment to the Trinidad area. At the close of the Miocene period gradual upheaval brought the oceanic deposits above the level of the sea, united Trinidad to the mainland, and dried up the Gulf of Paria; and the present distribution of land and water was brought about subsequently. (*Quart. Jour. Geol. Soc.*, xlviii. 519.)

EARTHQUAKES.

The Sound of earthquakes.

The sound varies, and is compared in different earthquakes to thunder, the rumbling of waggons, the firing of cannon, an explosion, the fall of heavy bodies, the roaring of wind, the hissing of hot iron, and loud and prolonged cheering. The sound in most cases begins faintly, continues to increase in loudness, and dies away gradually. When the sound is loudest, the principal vibrations are felt; but the sounds vary in the disturbed area in different places in intensity, duration, character, and their relation to the shock. The area over which the sound is heard is often very small compared with that over which the vibrations are felt. Sometimes the sounds are heard without any perceptible shock, and this condition characterises districts where slight shocks are frequently felt. The sound vibrations proceed from an area nearer to the surface than

the vibrations which cause the shock; and assuming that they are produced by fault-movement of the earth, the sounds are attributed to minute vibrations from the upper and lateral margins of the displaced area. If the amount of slip is very small, the sound extends over the whole area, and there is no other evidence of disturbance; but if there is any appreciable slip at all, a shock is felt; and when a slip takes place suddenly, and is of great amount, the sound may be confined to the lateral margins of the displacement. (**C. Davidson**, *Geol. Mag.* [3], ix. 208.)

British earthquakes in 1891.

Last year the British region was exceptionally free from earthquakes. On March 26th a slight earthquake was felt in the north of Cornwall, and recorded at sixteen places, showing that the point of greatest disturbance was about four miles north-east of Camelford. The area was seventeen miles long by thirteen broad. Two shocks were felt, of which the first was the stronger, divided from each other by an interval of some seconds. Earthquake sounds were heard generally. They preceded the shock at Michaelstow on the south-west, and followed it at Poundstock on the north-east. The sound of the first shock is compared to the rumbling of an unusually heavy waggon on a bridge, and that of the second was like the sound of a heavy ground sea after breaking on the shore. The focus of the second shock is supposed to have been south of the first, and at Boscastle the sound is said to have been heard during the whole interval between the shocks. The author assumes that the earthquake was due to fault movement. Shocks were felt in Inverness-shire, chiefly at Invergarry and Ardochy, in the months of February, March, April, August, November, and December. They were mostly accompanied by sounds compared to the movement of a heavy carriage. (**C. Davidson**, *Geol. Mag.* [3], ix. 229.)

THE ANDES OF ECUADOR.

Mountains, Glaciers, and Volcanoes of the Andes.

E. D. Whymper states that the Andes of Ecuador consist of one principal chain surmounted by a number of volcanoes, which are chiefly ranged in a north-to-south line towards its western edge, with a succession of basins on the eastern side. All the heights, with the exception of Sara-Urcu, are of volcanic origin. Some, like Cayambe, Antisana, and Chimborazo, are extinct; others, like Pichincha and Tunguragua, are dormant; while Cotopaxi and Sangai are in constant activity, and appear to be increasing in height. There is no record of eruption from Chimborazo; its

height is fixed at 24,980 feet, and the temperature of its summit in January was 21° F. The height of the snow-line in that month was a little below 16,000 feet on the south side, and nearly 1,000 feet lower on the east and north; and in June and July there was little snow on the west side below 16,700 feet, while on all other sides there was deep snow at 15,600 feet. The form of the mountain is much less regular than that of the active volcanoes. It has two summits, twin snowy domes crowned with glaciers, which stream down in every direction from a plateau on the top. One of the smaller of these, with a tongue-like form, named the Glacier des Débris, is 1,260 feet wide. Clouds on the upper part of the mountain are a permanent feature, owing to the condensation of vapour from the Amazonian region. The mountain is contained in a ridge 10 miles long, with precipitous cliffs descending from its summit ridge on the south, where it is covered with glaciers. These glaciers are described for the first time.

Corazon is 15,871 feet high, with a summit temperature of 43° F. The summit rock is a slate-grey augite-andesite, probably part of a dyke which rises as a great wall. On some days no snow is seen upon it, and on other days it is covered with snow down to 14,500 feet.

Illiniza is a peak with two summits. Its upper 2,200 feet is a large wall, possibly a dyke, which runs from north-west to south-east. A glacier extends almost to the summit of the eastern face, and there are one or more glaciers on the western slope. All the higher peaks of this part of the Andes are covered with glaciers. Cayambe, 19,186 feet, culminates in three domes or bosses, enveloped in glaciers covered with snow. Antisana has the upper 3,500 feet almost covered with snow and glaciers. It shows no signs of a crater; and though a crater is seen on Pichincha, it is much below the summit. The mountain termed Carihuairazo forms the northern end of the massif of Chimborazo, from which it is parted by a depression called Abraspungo. It is 16,500 feet high, has two principal peaks, and a third to the west. It is clothed with snow and ice, but the temperature registered at the summit was 38° to 40° F.

Cotocachi is a mountain in which the upper part is pyramidal, with a precipitous face to the east and a less abrupt face to the west, covered with snow. The true summit is a peak of purple-grey hypersthene-augite-andesite. Tradition says it was in eruption centuries ago; and it is suggested that the crater may be buried beneath the glacier which fills the depression between its two peaks. Its lower slopes are rent by a number of fissures,

The cracks are all very deep and V-shaped. They are attributed by Mr. Whymper to successive settlements at a time when the rocks were in a state of tension.

Sara-Urcu is the lowest of all the snow-peaks. It is south-east of Cayambe and about 45 miles north-east of Quito. Its elevation is 15,502 feet. It is not a volcano, for the summit is a shattered ridge of gneiss, strewn with fragments of mica-schist.

In most of these mountains the height of the January snow-line exceeds 15,000 feet, for many which exceed 15,000 feet have no permanent snow; but when the height exceeds 16,000 feet, as in Cotocachi, permanent snow may occur in large beds at 14,500 feet. In the extinct volcano Altar, which has the floor of the crater occupied by a glacier, there is snow below 14,000 feet. The glaciers of the Andes do not differ in essential features from the glaciers of the Alps. They attain the largest size on Antisana, Chimborazo, and on Cayambe, the latter possessing twelve which are named.

The active volcanoes are similar to each other in their modes of eruption. From Sangai steam was ejected at intervals of twenty to thirty minutes. It shot up with immense rapidity to 5,000 or 6,000 feet above the volcano, and then spread out in clouds of mushroom form, which were seen to drift ten or twelve miles south, demonstrating a north-to-south current in the air at 22,000 to 23,000 feet above the sea.

In ascending Cotopaxi, the other active volcano of Ecuador, Mr. Whymper experienced snow and hail every day, and on most ascents mist or rough weather was encountered. Isolated snow-patches commenced at 15,400 feet. The glaciers on the upper part of the cone extend to within 500 feet of the top. The face of the slope was inclined at an angle of less than 30° on the north and south, and about 32° on the east and west. The surface is covered with ash, so fine that 500 particles weigh no more than one grain, though they are intermixed with larger fragments which range up to a diameter of $\frac{1}{4}$ of an inch. The crater measures 2,300 feet from north to south, and 1,650 feet from east to west. At the bottom, probably 1,200 feet down, was a rudely circular spot, $\frac{1}{10}$ the diameter of the crater, filled with incandescent lava. The volcano is 19,613 feet high. At intervals of half an hour it blew off steam. It was perpetually active. As the steam issues from the crater it is carried first south-west and then north, and therefore it is interesting to note its position 43 miles south of the Equator. On 25th June, 1877, a black column rose from Cotopaxi 18,000 feet into the air. The wind blew the ash into the Pacific. Next day another great

column arose, and as it diffused the air at Quito at midday became intensely dark. On the following day lava was seen to pour through the gaps and notches in the lip of the crater, bubbling and smoking like the froth of a pot that suddenly boils over. In a few minutes there was a roar and a deluge of water; blocks of ice, mud, and rock rushed down, which were estimated to have travelled as far as Latacunda at the rate of 50 miles an hour, and the stream's mean rate of flow to Esmeralda, a distance of fully 300 miles, was about 17 miles an hour. In 1880 the dust, thrown up to a height of 20,000 feet in less than a minute, encountered a wind from the east, which carried the inky column rapidly in a horizontal direction towards the Pacific, where it was subsequently caught by a wind blowing from the north and blown southward over Chimborazo, covering the snow at its summit, and giving it the aspect of a ploughed field. It is stated that in the town of Amabato four ounces of this dust fell in a quarter of an hour upon a piece of paper a foot square. The majority of the particles weighed less than $\frac{1}{2500}$ of a grain. Mr. Whymper calculates that at least 2,000,000 tons were ejected in this dust eruption.

In examining the story told by Humboldt of the little fish, Pimelodus cyclopum, said to have been ejected from Cotopaxi, it is urged that the slopes of Cotopaxi, from 12,000 feet upward, are uninhabited, and that no one can affirm from personal knowledge that the fish were thrown from a fissure or crater 16,000 feet high. At a height of 19,500 feet on Cotopaxi water boiled at a temperature of 179°, and the evidence is not favourable to the belief that a subterranean reservoir at moderate temperature could exist so as to be emptied in an eruption. On the other hand, the fish is found in Ecuador in streams, ponds, and lakes, at from 8,500 to 10,000 feet above the sea. (*Travels among the Great Andes of the Equator.*)

GLACIERS.

Glaciers of the Caucasus.

D. W. Freshfield quotes M. Jukoff as authority for the dimensions of some of the glaciers of the Caucasus. That named Ulu-Chiran is 11·4 miles long and 580 to 1,170 yards wide. It ends at a level of 6,538 feet above the sea, where its ice is 214 feet thick. The glacier Mishirgi is formed of two branches. Its entire length is six miles, its lower extremity is 7,422 feet above the sea, and the ice is 425 feet thick. The melting of these glaciers gives rise to the Cherek Shkara River. A third glacier, Ulu-Auz, is 4·7 miles long and 700 yards wide. The effect of the annual thawing is to shorten the principal glaciers by between 70 and 80 feet.

The bulk of the moraines are found to consist of hard and clean ice covered with gravel and sand. Details are given of the dimensions of several other glaciers which are only a little smaller than those enumerated. (*Proc. Roy. Geog. Soc.*, xiv. 100.)

Glaciers in the Pamirs.

From a paper by **F. E. Younghusband** it appears that in the district which lies between Gilgit and Shigar on the upper waters of the Indus and the Oprang, which is a tributary of the Yarkand River, is a region containing the Gusherbrum Mountains (26,378 feet) and Mount Godwin-Austen (28,278 feet). From these mountains, and especially to the south and west of them, extends a maze of snow-fields and glaciers of large size. One of them, coming from the Gusherbrum Mountains, extends nearly across the valley of the Oprang, and terminates in a wall of ice 150 to 200 feet thick. Several other glaciers come down in the same district, one of which is described as 18 miles long, with an average width of half a mile, fed by three small glaciers on the west and one on the east. Its upper part is a smooth undulating snow-field, a mile and a half wide, where the snow is of a pale transparent blue colour. Lower down this névé is divided up by crevasses, which become larger as they descend, and then the surface of the ice is broken into a mass of domes, which become sharp needle pinnacles at a lower level. Lateral moraines preserve a gravel-like appearance at the sides, and wherever tributary glaciers join, the median moraines are continued down the valley to three miles from the Oprang River, where the ice is all melted down, and the glacier ends in a billowy mass of moraine, beneath which, however, caves and cliffs are seen in the solid white ice. Another glacier, called the Crevasse Glacier, is said to be 24 miles long, 1,000 to 1,200 yards wide, and terminates at 13,000 feet above the sea. Here, too, the lower extremity for more than two miles is covered with morainic matter. The author suggests that the glacier is retiring. Over a part of the Pamir the temperature fell more than 5° below zero. The Tagh-dum-Bash Pamir is 35 miles long, and varies from one mile wide in its upper part to four or five miles at its lower end. It is from 10,300 to 15,500 feet above the sea, inhabited by Kirghiz and Sarikolis, who are dwellers in tents. The snow does not clear away from the bottoms of the valleys till the end of May. (*Proc. Roy. Geog. Soc.*, xiv. 205.)

Glaciers in Sikkim.

Mr. Hoffman went up the Zemu Valley, and found its head closed by an immense glacier, which lies to the north-east of

Kanchinjimga. The glacier is a fortnight's journey from Darjeeling. The glacier appears to have been regarded previously as a moraine. The Zemu River descends from it through a narrow precipitous mountain valley. The glacier descends almost in a straight line; it is fed by a dozen tributary glaciers. Its sides are covered with lateral moraines, having the aspect of great embankments. (*Proc. Roy. Geog. Soc.*, xiv. 613.)

Mount St. Elias and its glaciers.

The southern shore of Alaska is bordered by lofty mountains, which rise directly from the ocean, and are clothed with hundreds of glaciers, which extend down to the sea-level. The only break in the coast is Yakutat Bay, fifty miles east of Mount St. Elias, which is computed to be 18,100 feet high, with a possible error of 100 feet.

The Augusta and St. Elias ranges are monoclinic upheavals of brown sandstone, and dark shales of great thickness, which dip to the north-east. The glaciers of this region are seen in many cases to extend in lines, in which the strata are broken and faulted. The lower limit of continuous snow, commonly termed the snow-line, is about 2,000 feet above the sea. The snow above that height feeds glaciers of the same type as occur in the Alps. The Seward glacier is fifty miles long, and three miles wide at the narrowest part. The glaciers, however, flow southward for fully 100 miles west of Yakutat Bay, and unite between the mountains and the sea into a continuous sheet, which has been named the Malaspina glacier. This ice-sheet extends 70 miles west, with a breadth of 20 to 25 miles, and is nearly horizontal, with a general elevation of 1,500 feet. It is greatly broken by crevasses, and has a rolling, undulating surface.

Seen from above, the clear, white ice is bordered on the south by a dark band of boulders, external to which is a belt of forest, 4,025 miles wide. Not only are moraines found along the external borders, but they stream off over the ice from the mountain spurs; that from the Samovar Hills crosses the entire breadth of the glacier, and joins the lateral moraine. The moraines have a tendency to accumulate, owing to the annual waste of the ice. On the stagnant borders of the Malaspina glacier there are many small lakes, both in the part of the moraine covered with forest, and in the outer, barren portion. They have walls of ice, of crater-like form, and usually drain eventually through a crevasse at the bottom. The forest growth on the moraines here in latitude 60° consists principally of the

spruce fir, sometimes nine feet in diameter, with cotton-wood, alder, and a dense growth of shrubs, bushes, and ferns. The vegetation upon the moraines has sometimes 1,000 feet thickness of ice beneath it. It is chiefly confined to the Seward lobe, which is the largest of the three great portions of this Malaspina glacier. Forests are also found on the northern border of the glacier. Their total estimated area is between 20 and 25 square miles. There is no visible surface drainage over the ice, and whenever streams appear they are swallowed up in crevasses; but along the southern margin hundreds of streams pour out from the border of the glacier, which rises like an escarpment. They are brown with sediment, and loaded with boulders. One of the largest streams is the Yahtse, which rises at the base of the Chaix Hills, flows through a tunnel six or eight miles long, and comes out from the glacier as a stream 100 feet wide and 15 or 20 feet deep. Another large stream is known as the Fountain; it is fully 100 feet wide, and the water rises 12 or 15 feet into the air, and, descending, becomes a river.

On the eastern margin the most interesting stream is named the Kame; it flows for half a mile in a narrow canon, with walls of ice 50 feet high, which eventually merge in a tunnel. (**Israel C. Russell**, *Amer. Jour. Sci.*, xliii. 169.)

ANCIENT GLACIERS.

Glen Roy.

The earliest and the latest interpretations of the parallel roads of Glen Roy attribute them to the waters of a lake held back by glacier ice, which sank to lower and lower levels as the glacial period passed away. **T. F. Jamieson** urges that since the rainfall on Ben Nevis is sometimes 145 inches in a year, and the fall over the west of Scotland is heavy north and south of the Firth of Lorne, the ice formed in the glacial period must be assumed to have been much thicker in the west than in the east. A line drawn from Ben Nevis, passing over the Moor of Rannoch to the head of Loch Lomond, marks the centre of what appears once to have been the greatest ice-field in Scotland; and another line drawn from the top of Glen Arkaig northward to Loch Shin may traverse the middle of an ancient ice-field, which appears to have been second in importance. These two ice-fields united at the western end of the Caledonian Canal. This western ice, unable to escape through the narrow channel, rose and overflowed the passes which led to the east. It filled Glen Gluoy, which runs between Glen Roy and Loch Lochy, and it also filled Glen Roy

and Glen Spean. This accumulation of the ice in the west is more obvious, because the evaporation produced less effect where the ice is thick than where it is thin. If the author's contention is admitted, that we may infer the ancient fall of snow from the modern fall of rain, then the retirement of the ice from the valleys into which it had overflowed becomes an intelligible explanation of the origin of lakes in such valleys. As soon as the ice melted out of the top of Glen Roy a lake would take its place, though at first it might be a superficial water resting on the glacier ice. As the ice retreated further down to Glen Glaster, on its east side, the lake followed it; and it was while the Glen was occupied by water in this way that the parallel terraces along its sides were deposited. It has been often urged that the Merjelen See in the Alps, which is held back by the Aletsch glacier, offers, in some respects, an illustrative parallel. Opposite Glen Glaster is Bohuntine Hill, and here the roads are well marked. The material of the roads is laminated mud, and gravel with angular fragments, such as ice might have accumulated below the water-line. But the alluvium at Bohuntine is attributed to the gravel and mud which fell into the lake from the front of the glacier when it barred the mouth of Glen Roy, while the upper two of the parallel ledges were forming. This deposit is regarded as having filled the bottom of the glen, but cut through by the retiring water as the lake was able to sink lower. After the ice retired from the entrance to Glen Roy it shot across the mouth of Glen Spean, extending between Tiendrish and Corry Choille. The ice of the Caledonian Canal probably filled the valley from Loch Ness down to Corran Ferry, and was increased by the glaciers from Ben Nevis. The lake was now four miles broad at the mouth of Glen Spean. The author is inclined to believe that when the water dropped 80 feet in level in Glen Roy, from the highest ledge to the middle parallel, there was probably a rush of water into Glen Glaster. He believes that the moraines of the Treig glacier have been broken and scattered, and that this result may have followed from such a débâcle. At the time of the lowest parallel road it is evident that the Treig glacier had retreated to the mouth of Loch Treig. The water appears to have drained away quietly when it finally retired from Glen Roy, since the old deltas, which were formed in it during the lacustrine period, have not been carried away. It has sometimes been urged that there ought to be evidences of a stream flowing out from the lake during the period when the highest parallel road was forming, and this the author considers he has found; and that as the stream descended to Glen Turret

a deep narrow ravine has been cut, and a great delta-like deposit was carried into the head of Glen Roy Lake at the time when Glen Turret formed the limit of the lowest of the parallel roads. Each of the roads is from 40 to 70 feet broad. Its slope towards the middle varies from 5 degrees to 30 degrees; but near the head of Glen Roy the highest road ceases to have width as it runs along the face of the rock, and in this position there are some water-worn pebbles. The deltas in the glen show that the lake existed for some considerable time. (*Quart. Jour. Geol. Soc.*, xlviii. 5.)

Subterranean erosion of the Glacial Drift.

In many places the glacial drift of Cheshire contains depressions which are occupied by peat. It is observed that the sands beneath the peat, which rest upon the more impervious clay, yield water, which is charged with a sediment derived from the underground erosion of the clay, sand, and gravel which the water traverses. Hence it is urged that irregularities of the surface result from the underground erosion. In the depressions thus slowly formed peat is found, often in successive beds. This is obvious in the three miles of the Manchester Ship Canal between Ellesmere Port and Ince Ferry. The author states that the principal characteristics of this kind of erosion is lateral subsidence. (**W. Shone**, *Quart. Jour. Geol. Soc.*, xlviii. 96.)

The supposed Inter-glacial Submergence.

It had come to be commonly believed that the great glaciation of northern Europe, which resulted in the formation of the Boulder Clay, was succeeded by a depression during which marine deposits were accumulated, in which sea-shells are found which include many northern species. Such deposits at Moel Tryfaen, nearly 1,400 feet above the sea, and at Macclesfield, about 1,200 feet above the sea, are paralleled by similar shell-beds at Wellington, in Shropshire, 500 feet above the sea, and those at Flamborough Head, 300 to 400 feet above the sea. After the submergence in which these deposits are supposed to have been formed the land was believed to have risen again, and a final glaciation took place in which the glaciers were comparatively small and local. But in 1874 the late D. Belt and J. G. Goodchild suggested that these shell-beds had been pushed up from the bottom of the sea, in advance of the glacier, and left in their present elevated positions. This view, favoured by Clement Reid, advocated by H. Carvill Lewis, is adopted by **G. F. Wright**, as the result of examination of the facts in England and Wales. The objections to the submergence

which weigh with him are that such a subsidence must have affected North Wales and central England, without affecting the South of England. There are no corroborative evidences of subsidence over the northern part of the centre of England. There is an absence on the Pennine Chain to the east of Macclesfield both of glacier deposits and beach lines. The shell-beds are confined to areas which were reached by glaciers, which moved over what are now shallow sea-bottoms, while the assemblage of shells is not such as would be found associated at the present day, and the valves of the bivalves are separated. If weight is attached to such considerations, it would follow that the glacial phenomena in England might be comprised under one glacial period. (*Amer. Jour. Sci.*, xliii. 1.)

FLEXIBLE ROCKS.

Flexible Dolomite.

The late Professor Sedgwick described a beautiful example of flexible magnesian limestone. **G. W. Card** finds a similar rock of this geological age abundant in the cliffs south of Sunderland. It is pale yellow, and contains minute nests of crystals of calcite. Experiments showed that a strip, 5 cm. long and $1\frac{1}{2}$ cm. thick, bent with its own weight through 1·6 cm., and broke when bent by pressure through 3·1 cm. The flexibility is attributed, first to the abundance of empty spaces in the rock, and secondly to many of the grains which form it being cemented together and so interlocked as to permit of movement upon each other. The nature of this relation is not demonstrated, partly owing to the small size of the grains, and partly because their margins cannot always be traced. The flexibility of the sandstone of Brazil, known as Itacolumite, like that of the similar sandstones in South Carolina and at Delhi, is attributed chiefly to the presence of a large amount of the elastic mineral mica in the planes of bedding; but there is good reason to think that the decay of felspar in the sand has liberated silica, which has become redeposited so as to unite some of the grains together by films of silica of great delicacy, which are perfectly flexible and elastic. (*Geol. Mag.* [3], ix. 117.)

Flexibility of limestone.

A slab of white crystalline limestone in the cemetery of Jefferson City, Missouri, supported upon four pedestals, is found, after 25 years, to have become bent, so that in the length of 6 feet the slab, 2 inches thick, diverges from the straight line $1\frac{1}{2}$ inch, which is $\frac{1}{35}$ of the distance between the supports. Assuming the curve to be the arc of a circle, this observation tends to show that such a

layer might be bent in 25 years so as to have the curvature of a circle 80 feet in diameter—an observation of some interest, and tending to account for some at least of the flexures and minor fractures of the strata. (**Arthur Winslow**, *Amer. Jour. Sci.*, xliii. 133.)

NATURE AND STRUCTURE OF OOLITE.

On the formation of oolite.

At the Bath meeting of the British Association, 1888 (Rep. 675), H. G. Seeley drew attention to the close resemblance which the calcareous internodal grains of nullipores show to grains of oolite, both in concentric and radiated structure; and G. K. Gilbert then mentioned that grains of oolite were in process of formation on the shores of the Great Salt Lake. Rothpletz states that these are snow-white calcareous corpuscles, thrown up on the low shore of the Great Salt Lake, where they form a substantial part of the beach sand. When seen beneath the water they are covered with the algæ Glæocapsa and Glæothece. The carbonate of lime is enclosed in the algæ in the form of rounded tubercles, which often mass themselves into larger irregular tubercular bodies. The materials thrown up on the shore may be either irregular tubercular masses several millimetres in diameter, or spherical or oval grains which are mostly the third of a millimetre in diameter; and with these are some rods half a millimetre long, by a tenth of a millimetre broad. Thus it is evident that the oolite of the Great Salt Lake is the product of fission algæ which secrete lime, and the deposition is proceeding day by day. The author states that there is a nucleus of sand in the grains of oolite now forming, which he examined, on the shores of the Red Sea. (**A. Rothpletz**, *Amer. Geol.*, x. 272.)

The physical structure of the Hirnant limestone.

This fossiliferous black pisolite consists of elongated grains, which owe their colour to a coating of carbon. The concretions of phosphate of lime in the Bala beds are also invested with carbon. When this pisolite is treated with acid the carbonate of lime is dissolved, and the carbon remains like a particle of soot; but when this residue is heated so as to drive off the carbon, the external shells become reddish-brown, and are found to consist of a little silica coloured with oxide of iron. Examined under the microscope, many of the grains show a concentric structure, but the radial structure, common in oolites, is rarely seen. The matrix in which they are embedded is crystalline calcite, with small grains of quartz, in which

moving bubbles are visible. The rock is compared in structure to the iron-ore of Cader Idris, Northampton, and Cleveland. (**L. W. Fulcher**, *Geol. Mag.* [3], ix. 114.)

ANTHROPOLOGY.

BY PROF. H. G. SEELEY, F.R.S.

The primitive flint implements of the chalk plateau of Kent.

The first flint implement of palæolithic workmanship observed upon a chalk plateau was found by Sir John Evans, in 1869, near Halstead, at 600 feet above sea-level. In 1885 Mr. Harrison began to search the drift plateau east of the river Darent, and has been rewarded by finding upwards of a thousand flint implements, which are mostly of a ruder type than those known previously from the valley gravels. These implements have now been collected over an east-to-west extent of 20 miles, between Caterham and the Medway, at levels which have varied from 400 feet up to 875 feet, at the summit of the chalk ridge of the North Downs. The most elevated specimens have been collected to the west of the Darent valley, by Mr. Crawshay. Professor Prestwich remarks that the rudeness of the implements alone does not demonstrate their antiquity; but moderately well-finished specimens are rare. They are all more or less stained of a brown colour; they are often very slightly trimmed, and the natural edges of the flint have been utilised in making the weapon. Mr. Harrison classifies the tools as crook-point tools, single-curved scraper, double-curved scraper, combination tool, split pebble with work upon one side, semi-circular tool, drawshave or hollow scraper (probably used for removing hair from skins), and tool for many kinds of work. They are often more suggestive of use in domestic industries than the more perfectly-shaped hunting implements found in the valley gravels. Their occurrence at these elevations probably indicates that they belong to an earlier period of time than the implements found at lower levels. (**J. Prestwich, B. Harrison, De Barri Crawshay**, *Jour. Anthrop. Inst.*, xxi. 246.)

Sculptured rocks of Algeria.

M. Flamand describes about twenty new stations south of Oran where inscribed rocks have been found. The prehistoric drawings

represent many types of animals and the human form. The artists drew with a sharp-pointed stone, and polished the surfaces, which are enclosed with a simple outline. The animals represented comprise the lion, tiger, panther, hyæna, jackal, a gigantic buffalo with enormous horns, which is easily recognised as the extinct Bubalus antiquus. Another animal resembles the zebra; there are many antelopes, a sheep, horses, apes, many elephants, and giraffes. The Rhinoceros bicornis is identified with some doubt. Some wading birds appear, with the ostrich and ibis. The human figure is rare, almost unclothed, and is represented with six fingers on each hand in one drawing. One man holds an axe of similar type to the polished stone weapons used by savages. Some figures have the head ornamented with feathers, and the body bound with a girdle.

In the district are rock shelters in soft sandstone, partly excavated by water, and enlarged by man, in which are found numerous remains of primitive industry, including worked flints, many kinds of arrow-heads, needles, knives, and scrapers. At a depth of a few centimetres are polished weapons of a green ophite, sometimes 25 to 30 cms. long. Explorations at Djebel Mahisserat have yielded charcoal, pottery devoid of ornament, and a large perforated shell of the genus Murex, which was probably used as an ornament.

Associated with these early inscriptions are later drawings of Lybico-Berber age, which represent southern animals; and finally there are early Arabic inscriptions in the same region. (*L'Anthropologie*, iii. 145.)

The ancient inhabitants of Mashonaland.

No more singular discovery has been made recently than that of the great Zimbabwe ruins in South Africa. **J. T. Bent** describes the remarkable birds perched on long soapstone pedestals which decorated the outer wall of the semicircular temple on the hill as being proved by the beak to represent vultures or hawks, though the thick neck and legs, long talons and plumage, rather indicate the vulture. They appear to be associated with some symbolism, for one has two circles carved under it, and two on the wings; and another is perched on a chevron pattern. The author recalls the ancient symbolism of maternity by the vulture; and regards these images as comparable to some described by Lucian in a temple at Hierapolis, near the Euphrates. There also appears to have been a close correspondence in plan between the Zimbabwe ruins and that temple. On one of the soapstone bowls found in the ruins is a fragment of a

procession, indicating a hand holding a pot, containing some offering, and an arm of another figure with a portion of the back of the head, on which the hair is drawn up in folds, which recalls Assyrian sculpture. From this Mr. Bent infers the foreign origin of the builders of the ruins of Zimbabwe; and believes the conclusion that they came from northern regions to be evidenced by the fact that they placed the tower and fortress on the southern or shady side of the hill; whereas Kaffirs always prefer the sunny side. A fragment of another bowl has on it an elaborate design taken from some plant with a spathe and an ear, which closely resembles an ear of corn. On a third fragment is an indication of an inscription, but no attempt is made at deciphering the supposed letters. Another bowl has a procession of bulls around it, characterised by very long horns, which vary in position in different individuals. It is interesting to remember that remains of a buffalo (*Bubalus Baini*) with very long horns have been found buried in the river drifts of the northern part of Cape Colony.

With these and other bowls were found, near to the surface, a few fragments of Persian ware, of Celadon pottery from China, and a specimen of Arabian glass, and beads, one of which is regarded as Egyptian of the Ptolemaic period. Close underneath the temple was a gold smelting furnace, made of a hard cement of powdered granite; and near by were the rejected quartz crushings from which the gold had been extracted. Near the furnace were many small crucibles of clay, in nearly all of which specks of gold adhered to the interior glaze. In several places there are long rows of stones for crushing quartz, sixty or seventy in a row. There is evidence that the gold-workers of Zimbabwe were acquainted with the art of plating, one spear-head being gilt in this way. There are bells found such as are now made on the Congo, and the ironwork, which includes chisels, adze, and spades, points to a higher civilisation than that of the modern Kaffir. Mr. Bent concludes that the remains are older than the Mohammedan period, and that the evidence favours an Arabian origin. (*Jour. Anthrop. Inst.*, xxii. 124.)

Burials in Russia.

In the fourteenth, fifteenth, and sixteenth centuries the use of the sledge for conveyance at funerals was common, both in winter and summer; but in the seventeenth it appears to have been regarded as an ancient custom, though still used at the funerals of royal persons. It is well known that the sledge was used at funerals in ancient Egypt; and it is not less remarkable that it was also used in royal marriages, and continued to be

used by the Patriarchs of Moscow long after wheeled carriages came into use. The peasants of the Government of Vologda take their dead to the cemetery in a sledge, which they turn upside down, and leave on the grave. The man's arms are buried with him, and his reindeer slain; as is also the custom with the Finnish tribes on the Volga, and at the foot of the Ural range.

The Ostyaks of the Obi have the custom of burying their dead coffined in the front half of a boat, a custom which is thought to have probably arisen from the need of crossing a river to reach the happy hunting-grounds. It is recorded that in the tenth century, on the Kama tributary of the Volga, the burial custom for the poor man was to place the body in a small boat and burn it.

In other parts of Russia horses are buried with the dead, but the custom is more frequent in eastern Russia and Siberia than in the west. Often, instead of burying the whole horse, only a part of its skeleton is used, commonly the skull or leg bones; and the bit and stirrups are laid on the grave. The Croats borrow horses for use at funerals, that the deceased may have no claim on them. The last instance of killing a horse at a funeral in Germany occurred in 1781. The custom survives in the habit of taking the horses of soldiers and royal personages to the grave, though the significance of the custom has been forgotten. (**D. N. Anuchin**, *Jour. Anthrop. Inst.*, xxi. 321.)

Phœnician burial.

M. Haunezo describes some examples of Phœnician sepulchres found near Mahédia, in Tunis, and finds proofs that the dead were sometimes buried and sometimes burned. When burned, the bones were collected in an urn, which was placed in a cave. When burial was practised, the body was deposited in a cave, either upon a natural surface of tufa or, more frequently, in a wooden coffin, which was deposited upon the tufa. The head is towards the wall opposite to the entrance. The place of burial was reached by a staircase, obstructed by fragments of excavated rock, and was shut off by a door of tufa flagstone. The skulls found were examined by M. Collignon. One skull of an old man has a cubic capacity of 1617 cubic cms. It is clearly dolichocephalic, with the superciliary ridges and glabella very pronounced, and a general prognathism. The palatine arch is deep. It is best paralleled by Gond skulls from India, in which the author suggests that the Phœnician type may be represented. (*L'Anthropologie*, iii. 161.)

Marriage customs of the Ukrain.

T. Volkov gives an account of the rites and marriage-customs of the Ukrain, which are in some respects primitive and barbaric. The colour in use for flags is red, the wine is tied up with red ribbons in some districts, and the headdresses of the men and women are decorated with the same red colour. At the close of the social observances the young people are taken to church, where the bride goes through the ceremony of having her head covered with white muslin. If there is no church accessible, the same ceremonies take place by the side of a well. On returning to the house the head-covering is removed with a stick, or with the hand. Bread and honey is eaten. The wedding-feast lasts sometimes for seven or eight days ; and at its close the newly-married couple return the visits of all their friends, taking with them in some localities seven cakes to each. In the Government of Poltava the parents are crowned when their last daughter is married. In all the marriage observances the mother of the bride and mother of the bridegroom take the most prominent parts. It is the mother from whom the bride is demanded ; she gives her blessing. The songs are addressed to her while the bride's hair is cut ; she conducts them to church, throws salt over them, and presides over all the other ceremonies. The mother of the bridegroom takes her son to the bride's house to receive the benediction, and awaits the party in the church. The author believes that all the primitive steps in the evolution of marriage are preserved and symbolised in the customs and ceremonies of the Ukrain. (*L'Anthropologie*, iii. 541.)

Skull characters in the North of France.

R. Collignon, examining the physical characteristics of the Côtes-du-Nord people, finds at Guingamp that the brachycephalic Celtic race of Broca is manifest. At St. Brieuc this race is intermixed with a southern brachycephalic element. At Dinan the predominant type is the dolichocephalic blond. At Loudéac these two types are irregularly mixed. At Lannion there is a notable percentage of the ancient Cro-Magnon race, which has the face large, with the skull brachycephalic and small, and hair and eyes brown. These people are intermixed with dolichocephalic blondes, and brachycephalic brunettes. The characteristics thus indicated, although very obvious in central types, show many gradations towards each other, for the crossings of races have been many and varied, and no man of pure race remains. (*L'Anthropo-rie*, iii. 43.)

BIOLOGY (ANIMAL).

ZOOLOGY AND COMPARATIVE ANATOMY.

By C. HERBERT FOWLER, B.A., Ph.D.*

EMBRYOLOGY.

Maturation, fertilisation, and segmentation of the ovum.

Henking brings together the conclusions derived from his series of memoirs on the developmental processes of the Insectan ovum. The following are among his most interesting results, but there are variations in the phenomena according to the genus examined. The chief part of them rest on Pyrrhocoris. The cells of the germarium, the follicle cells, and the ordinary tissue cells of the body, all have before division *twenty-four* chromosomes in their nuclei, and these in division split, so that there are twenty-four chromosomes in each daughter nucleus. In the case of the mature ovum, however, only *twelve* chromosomes are present; in the formation of the first polar body these also split (without any appearance of polar rays or centrosomata), the two halves being connected by achromatic fibrils, in the equator of which is a "nuclear plate." In the process of constriction to form the polar body, this achromatic nuclear plate is left behind in the ovum to form the "thelyid;" the second polar body is formed in the same way, so that the ovum, when ready for fertilisation, has (like the spermatozoon) half the number of chromosomes possessed by an ordinary cell. Many spermatozoa may enter the ovum without producing apparent abnormality (*cf.* Hertwig, p. 362), only one was ever seen to copulate with the nucleus of the ovum. The fate of the superfluous spermatozoa, and of the polar bodies, which are reabsorbed into the egg, was not traced. An "Arrhenoid" which Henking describes as formed out of the tail of the

* Dr. Fowler was unavoidably prevented from completing his contribution to this section, and the Editor is indebted to R. I. Pocock, Esq., and R. Lydekker, Esq., for supplementary matter. The paragraphs contributed by the former are marked with an asterisk; those by the latter form a separate section.

spermatozoon, resembled in its behaviour the centrosomes described last year. ("Year-Book" for 1891, 337.) The polar bodies may divide and fuse. A marked synchronic rhythm was observed in the division of the ovum-nucleus, the polar-body nuclei, and the spermatozoa; as many as ten nuclei may be going through the same changes at the same moment, though only one of the male and one of the female appear to take part in the actual development of the embryo. He concludes with a brilliant comparison between these phenomena and those recorded by Maupas in his classic paper as occurring in the conjugation of Infusoria. Henking also describes the formation of the polar bodies in the parthenogenetic ova of Rhodites, Bombyx, and Lasius. (*Zeit. wiss. Zool.*, liv. 1.)

Although differing from Henking in details, the main conclusion at which **Häcker** arrives with regard to the number of chromosomes is essentially the same. He has selected Copepodan ova for his study; in ova of Canthocamptus the nuclear filament is resolved into twenty-four double-chromosomes, these are transformed into four rods, each consisting of six of the former; two rods are ejected with the first polar body, one with the second, the fourth containing the chromatic substance for the nucleus of the unfertilised ovum. Here the chromosomes are first doubled, then quartered, the total result being, as in Pyrrhocoris, that the ovum contains half the right number, which is brought up to the normal by fusion with the spermatozoon. (*Zool. Jahrb.*, v. 211.)

Ishikawa approaches the same subject with a study of Copepodan Spermatogenesis and Ovogenesis. (*Journ. Coll. Science*, Tokyo, v.) **Vom Rath** has attacked Spermatogenesis in Gryllotalpa, and his results are again slightly different from those of other observers. In his paper will be found a summary of recent observations on the subject. (*Arch. mikr. Anat.*, xl. 102.)

In Pristiurus also **Rückert** finds that in the ovum, when preparing for the formation of polar bodies, etc., a doubling of the chromosomes occurs; in this form the number is not, however, always the same in every ovum, from thirty to thirty-six are to be found in the primitive ovum and the ordinary tissue, sixty to seventy-two in the maturing ovum. From their position it is obvious that the multiplication is effected by the usual process of longitudinal splitting of the chromosomes. A shortening and fusion then occurs, till just before the disappearance of the nuclear membrane there are only about eighteen present, *i.e.*, half the number present in ordinary cells. These probably split in the formation of the first polar body, since alike in it and the ovum eighteen are to be found. The author believes that a similar

process occurs in the formation of the second polar body, but his observations here are less precise. If this be so, here also the number of chromosomes in the ovum before fertilisation would be half that of the ordinary tissue cells. (*Anat. Anz.*, vii. 107.)

Rückert also points out in a second paper that at any rate the greater number, if not all, of the yolk-nuclei (= parablast nuclei or merocytes) of fish ova are the nuclei of supernumerary spermatozoa, that they undergo karyokinesis (cf. Oppel, "Year-Book" for 1891, 338, and his fuller paper this year, *Arch. mikr. Anat.*, xxxix. 215). In their division the number of chromosomes is half that of the ordinary tissue cells. (*Anat. Anz.*, vii. 320.)

Driesch, continuing the remarkable experiments chronicled last year ("Year-Book" for 1891, 340), shows that not only after the destruction of one of the first two segmentation spheres of the Echinidan ovum, a perfect but small pluteus is produced, but also that a similar result may be obtained by the destruction of either one or three of the first four blastomeres. He further finds that by pressure on the ovum, so as to turn the nuclear spindle in karyokinesis at right angles to its natural position, the direction of the segmentation may be completely altered; by thus pressing on a four-celled stage, of which the next segmentation furrow would normally be equatorial and produce an eight-celled stage, four above four, he achieved an eight-celled flat plate, the furrows being thus artificially made meridional. These remarkable facts appear only in a preliminary note; but the author claims to show that the results of segmentation are equivalent in different material, of which any part may become either a complete individual or any part of one. (*Anat. Anz.*, vii. 584.)

Roux, summarising his own work and that of others on artificial teratology resulting from destruction of the segmentation spheres, endeavours to show that the differences of opinion between them are reconcilable. His own previous observations showed that on the destruction of one of the two first segmentation spheres of the frog, a half-morula was produced, followed by a half-gastrula and half-embryo; to this he now adds that in several cases a "post-generation" occurs resulting in the conversion of the half-embryo into a small complete embryo. He therefore concludes, on a comparison with the results of Driesch, Chabry, Hertwig, etc., that in the three classes of Chordata, Echinodermata, and Coelenterata, a destruction of one of the first two segmentation spheres, or its separation from the other, produces a Hemiplast, or bisected embryo; that after this, either at once (Echinus and Ascidia) in alecithal ova, or later (Rana, Ctenophora) in highly-yolked ova, a post-generation of the missing

half takes place, resulting in the production of a tiny whole, which he terms a Hemiooholoplast or Mikroholoplast. (*Verh. Anat. Ges.*, vii.)

Clapp has noted the relation of the axis of the embryo to the plane of first cleavage of the ovum in Batrachus tau: a point of some importance in connection with recent views in the "predestination" of the egg. Of twenty-three cases, the two coincided in three; the head was to the right of the cleavage plane in fourteen cases, the long axis of the embryo making an angle of 30° to 70° with it; in six it was to the left, the angle varying as before. (*Journ. Morph.*, v. 494.)

INVERTEBRATA.

Cœlenterata.

Zoja describes a complicated nervous system in Hydra, obtained by the methyl-blue method of staining living tissue, which has recently yielded such interesting results. Only a preliminary note has at present appeared. (*Zool. Anz.*, xv. 241.)

Brauer, whose interesting paper on the development of Hydra was chronicled last year ("Year-Book" for 1891, p. 342), has investigated the development of Tubularia, with the view of ascertaining whether the so-called morula-stage, occurring also in this ontogeny, did not here, as in Hydra, represent the two-cell layered embryo; he finds that it does so, the inner cells being the true endoderm. (*Zeit. wiss. Zool.*, lii. 551.)

Albert Lang shows that in the gemmation of certain Hydrozoa the whole bud is formed from the ectoderm of the parent. The process of gemmation consists of a multiplication of ectodermal (interstitial) cells, of which some, on the reabsorption of the mesogloea, wander inwards, replacing and pushing before them the true endoderm cells: they become continuous with the true endoderm at the sides of the gemmation-area, but the cells which they replace are thrown into the cœlenteron and reabsorbed. A remarkable feature of the investigation is that it was suggested to Lang by Weismann on the purely theoretical ground that the "Knospungs-idioplasma" must lie in the ectoderm, not in both body-layers. (*Zeit. wiss. Zool.*, liv. 386.)

Schlate has worked at the "colletocystophores" or "marginal anchors" of Haliclystus (Lucernaria) and regards them as very simple tentaculocysts, *i.e.*, sense organs modified from tentacles, resembling those of other acraspedote medusæ, but at a lower grade of complication. (*Zeit. wiss. Zool.*, lii. 580.)

*** A. Alcock, M.B.**, records an interesting case of commensalism occurring between a Hydroid polyp (Stylactis minoi, sp.n.) and

a Scorpœnoid fish (Minous inermis, sp. n.). The two species are invariably found associated together in the Indian Ocean. The polyp is usually attached to the throat or near the gill-openings of the fish, and no doubt benefits by securing for itself particles of the food that the latter is devouring. The fish, on the contrary, which is remarkable amongst its allies for the thinness of its skin and the feeble development of spine-armature, and thus stands in need of some protective agent, is doubtless partially concealed by the Hydroid alike from enemies and from unsuspecting prey, and is, moreover, protected from the assaults of many of tho former by the urticating property of the polyp. (*Ann. Mag. Nat. Hist.* [6], x. 207.)

Porifera.

The most bewildering chapter in embryology is undoubtedly that which relates to the sponges. The development of Esperia chronicled by **Maas** has not made it much clearer. The free swimming larva is oval, and is covered over some five-sixths of its surface by slender columnar ciliated cells with small nuclei. The posterior sixth is, like the central mass, composed of non-ciliated cells with large nuclei. The larva fixes itself by the anterior pole, and the cells with small nuclei come to be included in the others, apparently by a sort of epibole, and then form a mass in the lower part of the sponge; they give rise to the lining of the ciliated chambers and canals, the other, now exterior cells, form the outer layer of the sponge, and line the subdermal spaces. The author is expressly careful not to mention the terms, but the (originally) outer layer of ciliated cells is doubtless what is generally termed ectoderm, the (originally) inner layer endoderm. The segmentation was not, however, followed. (*Mittheil. zool. Sta. Neapel*, x. 408.)

Zykoff gives in a preliminary note (*Zool. Anz.*, xv. 95) his conclusions on the development of the gemmules in Ephydatia (Spongilla) fluviatilis. They commence by the appearance of yolk spherules in certain amœboid cells; these become surrounded by parenchym cells, but, *pace* Goette, neither the ciliated chambers nor canals take any part in their formation. The peripheral parenchym-cells become radially arranged and club-shaped, and secrete chitin at their central ends to form the inner shell. He further states that the amphidiscs are formed, not inside these club-shaped cells, but outside and beyond them, but does not state by what cells they are secreted. The club-shaped cells then work their way on to the surface of the amphidiscs, and deposit the second chitinous layer.

* **J. Hornell** has discovered in Jersey a case of commensalism between a red sponge (Microciona plumosa) and an annelid (Leucodora cæca). The apertures of the worm-burrows could be counted in numbers on the surface of the sponge. Mr. Hornell explains the commensalism as follows: he imagines that the sponge gains considerable support from the wiry tubes of the worm, and possibly food from the excreta; whereas the worm finds a protector in the sponge, which is spicular and characterised by an intense smell of garlic, and very possibly gets food from the water-currents set in motion by its cilia. (*Nature*, xlvii. 78.)

Minchin continues his work on sponges. He has studied at Naples the Leucosolenia (Ascetta) clathrus, which is generally supposed to be devoid of an osculum. Not only does it prove to have oscula, but Haeckel's Ascetta labyrinthus, A. mæandrina, A. clathrina, and A. mirabilis, are merely this sponge in different stages of contraction. The author agrees with Topsent in regarding the contractile elements as derived from ectodermal epithelium. (*Quart. Journ. Micr. Sci.*, xxxiii. 477.)

Echinodermata.

In the development of Amphiura squamata **Russo** finds confirmation of the theory, advanced last year by Brauer, that an unipolar formation of mesoderm takes place in free swimming blastulæ, but a multipolar formation in cases where development occurs in a limited space. While in the generality of Echinoderms the early development occurs free in the water, and the formation of the two-cell-layered embryo is effected by invagination, in Amphiura development takes place in the body of the mother, and the endoderm is formed by delamination. An interesting feature in this development is that the figure illustrating the delamination is precisely like the well-known figures illustrating the hypothetical development of metazoa from protozoa on the delamination theory of the gastrula. The cells of the blastula are at their peripheral ends transparent and yellow, but centrally are red and opaque with yolk; it is this central end which is cut off to form the endoderm by delamination. (*Zool. Anz.*, xiv. 405.)

The most important of **MacBride's** results is the origin of the genital cells in Amphiura squamata from cœlomic epithelium, thus bringing them in a line with other Cœlomata. The ovoid gland arises from a portion of the rudiment which gives rise to the primitive germinal cells, as a solid organ. (*Quart. Journ. Micr. Sci.*, xxxiv. 129.)

Chætopoda.

Cerfontaine confirms Friedländer's conclusion as to the nervous nature of the giant fibres in the nerve-cord of the earthworm. According to him they are fibres of a very special nature. The median one takes origin anteriorly, and is directed backwards; the lateral ones, which are occasionally in communication by connectives, originate posteriorly, and run forwards; their function is to make longitudinal connection between the different parts of the nervous system.

Lenhossék has studied the nervous system of Lumbricus with the aid of the methyl-blue method, which has lately yielded such splendid results. He finds that the sensory nervous system of the earthworm lies in the epidermis, in the shape of nerve-cells among the columnar supporting cells, which give off nerve-fibres ending in the nerve-cord. This condition he regards, as others have done, as indicating a primitive developmental grade, but one in which a differentiation has already taken place, a yet earlier condition being that in which all cells alike were sensory. He maintains that in the earthworm, as in all animals, vertebrate and invertebrate alike, there are no nerve-fibres which terminate at both ends in nerve-cells: an epidermal nerve-cell is not a "nerve-end-cell," but the cell of origin of a nerve-fibre. In the higher animals the primitive condition of the earthworm is altered in two directions, the sensory nerve-cells of the epidermis are either accumulated in special spots as organs of special sense, or else, like the motor cells, sink inwards from the surface; some, however, always remain on the surface—*e.g.*, cells of the lateral line and "taste-bud" cells of the tongue and nose, both of which kinds are to be regarded as cells giving origin to nerve-fibres. As His surmised and Golgi proved for vertebrata, the nerve-fibres from these sensory epidermal cells branch freely in the nerve-cord, and do not enter other nerve-cells. (*Arch. mikr. Anat.*, xxxix. 102.)

Lortet and **Despeignes** buried fragments of consumptive lung in flower-pots, and found that six months afterwards the earthworms placed in the pots for experiment were highly charged with the tubercle bacillus. They are of opinion that, as Pasteur showed twelve years ago, earthworms are a serious danger in bringing septic bacilli to the surface of the ground from buried bodies. (*Comptes Rendus*, cxiv. 186.)

Beddard gives good grounds for believing that Æolosoma may temporarily encyst itself, a power not hitherto recorded of any chætopod. (*Ann. Mag. N.H.* [6], ix. 12.)

Vejdovsky confirms these observations of Beddard from his

own experience; and relates a comparable phenomenon in earthworms. He has noticed that both in confinement and in a wild state older worms sometimes become thin and retire to roundish holes in the earth, which are lined by a fine membrane comparable to a cyst, and in which the worms are rolled up in a skein or spiral. The clitellum and genital openings become unrecognisable, no food is found in the alimentary canal, and the animal becomes extremely transparent. He regards the process as probably connected with reproductive rejuvenescence. (*Zool. Anz.*, xv. 171.)

Turbellaria.

Vogt mentions briefly a case of a (? temporarily) parasitic Turbellarian of the genus Gunda encysted on a murænid larva. (*C. R. Ass. Franc.*, 1891, pt. i., p. 239.) This parasitism has not been previously observed in this group.

Nemertina.

Du Plessis has found, under shingle at the lake of Geneva, numerous specimens of a true tetrastemmid Nemertine, in full reproduction. (*Zool. Anz.*, xv. 64.)

De Guerne gives a summary of the recorded occurrences of Nemertines in fresh water, in connection with this discovery. (*C. R. Soc. Biol.* [9], iv. 360.)

Nematoda.

Ritsema Bos. gives a long account of the maladies produced in various plants by the ravages of Tylenchus devastatrix, of the highest interest, but too long to detail here. (*Arch. Mus. Teyler.* [2], iii. 545.)

Acanthocephali.

Stiles brings forward some evidence to show that Lachnosterna serves as secondary host for Echinorhynchus gigas in America, where the European hosts, species of Cetonia and Melolontha, do not occur. The worm appears to infest swine to a great extent near Washington. (*Zool. Anz.*, xv. 52.)

Chætognatha.

Jourdain states that the mode of origin for the mesoderm in Sagitta, described by Kowalewsky and Bütschli, namely, from a pair of archenteric pouches, does not occur. The matter is of some interest on account of the general resemblance in development between Sagitta and Amphioxus. According to Jourdain the two lateral lobes are formed, but disappear, and the meso-

derm is formed by delamination from ectoderm and endoderm. (*Comptes Rendus*, cxiv. 28.)

Polyzoa.

Experiments with carmine, indigo-carmine, and Bismarck-brown, have been made by **Harmer** with a view to ascertaining the nature of excretion in Polyzoa. The organ affected by these pigments in suspension varied according to the pigment used and the species selected for the experiment; the leucocytes, the alimentary canal, and the funicular tissue were so affected. The pigments taken up by the alimentary canal were mostly passed into the "brown body," which is formed by degeneration of the polypide apparently under the stimulus of the pigment; the leucocytes when charged with pigment appear henceforth to take no further part in the life of the animal. On regeneration the tissues of the new polypide are entirely free from pigment. The author regards the three organs mentioned as the chief source of normal excretion, and agrees with Ostroumoff in holding the "brown body" with its natural pigment to be a means of normal excretion correlated with the absence of nephridia in this group. (*Quart. Jour. Micr. Sci.*, xxxiii. 123.)

Arthropoda.

* **E. Whymper** has made some observations of the highest importance upon the vertical range of animal life in the Andes of Ecuador. Upon the whole it seemed that most species had a comparatively small range in altitude. Two species, however, were an exception to this rule, a moth (Erebus odora) occurring both at the sea-level and 10,000 feet above it, and a wood-louse (Metoponorthrus pruinosus), which was found just outside Guayaquil and as high as 13,300 feet on Antisana. One species of butterfly was found upon nearly all the mountains between the elevations of 12,000 and 16,000 feet, but it was neither taken nor seen in any of the basins between the mountains. So, too, were many beetles restricted to high elevations on the mountains, and were not found in the valleys. Thus Helicorrhynchus vulsus and Macrops cœlorum were discovered at 15,500 feet on Pichincha and at 16,000 feet on Chimborazo. From Whymper's highest-point table it appears that grasshoppers were met with on Chimborazo as high as 16,000 feet, and a species of centipede (Scolopocryptops mexicanus)—a widely distributed neotropical form—on the same mountain as high as 13,300 feet. Spiders were found on the summit of Corazon 15,871 feet, on Chimborazo up to 15,811

feet, and on the summit of Pichincha at 15,918. (*Travels amongst the Great Andes of the Equator*, 351—366.)

Crustacea.

Groom gives a different orientation to Sacculina from that usually accepted, in regarding the visceral portion of the adult as a fusion of head and thorax. (*Proc. Camb. Phil. Soc.*, vii. 160.)

Viguier has repeated the experiments of Groom and Loeb on the heliotropism of the nauplius larva of Balanus perforatus; but is unable to arrive at the same results. After being shut up in a photographic "dark room" they should, according to Groom and Loeb, all swim to the light (positive heliotropism), and after being exposed to it for some time should swim away from it (negative heliotropism). Viguier, however, found that on exposure to light after darkness the larvæ separated into two groups + and —, the — being generally larger than the +, and that gradually more and more — came over to the + side, till at the end of nine hours the — group was as large as the + group had originally been. On removing the + and placing them in another vessel they separated into + and —. Whatever law governs their movement, it is more complicated than Groom and Loeb suspected; and Viguier declines to admit that it governs the vertical movements of the pelagic fauna. (*Comptes Rendus*, cxiv. 1489.)

Gruvel has made some observations showing that reciprocal fertilisation occurs in Balanus and Lepas, the penis being introduced between the valves of a neighbouring shell. (*Comptes Rendus*, cxiii. 706.)

Marchal furnishes a very full account (*Arch. Zool. Exp. Gén.* [2], x. 57) of the antennary glands of Decapoda; he does not believe the nephro-peritoneal sacs to be portions of a true cœlomic cavity. (*Cf.* "Year-Book" for 1891, 348.)

Giard and **Bonnier** have submitted the rare Cerataspis (Cryptopus) to a renewed study, and conclude that it is "a penæid tending towards a brachyurous condition," thus attacking a recent paper of Van Beneden, who assigns it to the Schizopoda. (*Comptes Rendus*, cxiv. 1029.)

Heim, like many others, has submitted the blood of Decapoda to physiological and chemical examination. The most important of his conclusions is that hæmocyanin differs from hæmoglobin in the absence of a metal in the molecule; that the copper present in the blood is an accidental element, and not combined as an albuminate. (*C. R. Ass. Franc.*, 1891, pt. 2, 586; and *Comptes Rendus*, cxiv. 771.)

Weldon has continued his attempts to estimate variations on a mathematical basis. In a former paper he showed that the variations in size of certain organs of the shrimp occurred with a frequency practically identical with that indicated by the law of probability. Taking now the total length of the carapace, and comparing it with the length of that portion which lies behind the last spine, he finds that if these measurements be expressed in terms of their probable error, when the one differs from the average by any constant amount, the deviation of the other will be 0·80 to 0·85 times the deviation of the former; in other words, the correlation between the two lengths is expressible as a mathematical constant. A large series of such specific constants would give an altogether new kind of knowledge of the physiological connection between the various organs of animals; while a study of those relations which remain constant through large groups of species would give an idea, attainable at present in no other way, of the functional correlations between various organs which have led to the establishment of the great subdivisions of the animal kingdom. (*Proc. Roy. Soc.*, li. 2.)

* **A. Alcock** has made some observations upon the habits of the red ocypode crab, a terrestrial species which is common in some parts of India. This crab lives in holes in the sand, and although gregarious in the sense that numbers frequent the same spot, it appears that only in one respect is there social combination between the various individuals of the community. It has long been known that the species of Ocypoda are furnished with a highly developed stridulating organ upon one of the chelæ. Mr. Alcock has noticed that each crab has a burrow to itself, and that if one of them, as often happens in the case of a panic, attempts to enter by mistake the burrow of another, the rightful occupier stridulates to warn the intruder of its error; whereupon the latter immediately retreats in search of its own abode. So strong is this instinct against trespassing, that a crab will always undergo the risk of a fresh run for safety, rather than persevere in seeking concealment in the burrow of another. It is suggested that the benefit of this instinct is the avoidance of all ills, such as suffocation and blood-shed, which might result from overcrowding in the burrows. (*Ann. Mag. Nat. Hist.* [6], x. 336.)

* The same author has closely watched the habits of the calling crab (Gelasimus annulipes), which is remarkable amongst other things for the enormous development and bright red colour of one of the claws in the male. Mr. Alcock has noticed a number of examples of this sex waving their large chelæ in the presence

of a female, and he concludes that their object in so doing is to make a display of their gaudy ornamentation, and by thus pleasing her æsthetic taste influence her choice of a mate. (*Ann. Mag. Nat. Hist.* [6], x. 415.)

* **W. Hardy** has shown that the freedom of Daphnia from external parasites, a feature in which it contrasts forcibly with Cyclops, is to be attributed to the presence of a slimy film, which is secreted by the external layer of the skin and envelops the whole body. No such substance could be detected in Cyclops. (*Jour. Phys.*, xiii. 309.)

Insecta.

Keller describes a new case of symbiosis between ants and acacias, the first authenticated instance in the old world, from Somaliland. An additional interest is lent to the tree by the fact that the white swollen thorns inhabited by the ants are mimicked by the cocoons of a spider, which, like them, are evenly set in pairs on the branch. (*Zool. Anz.*, xv. 137.)

Nicholas has made some experiments at Mont Ventoux on the retardation of the date of hatching in hymenoptera, produced by high altitudes. His results are sufficiently interesting to be reproduced :—

At the height of		20	metres, the	retardation	amounted to	0	days.
"	"	600	"	"	"	25	"
"	"	860	"	"	"	41	"
"	"	1.253	"	"	"	69	"
"	"	1,400	"	"	"	83	"
"	"	1.700	"	"	"	98	"
"	"	1,912	"	"	"	117	"

(*C. R. Ass. Franc.*, 1891, pt. ii., 566.)

Verhoeff has some interesting observations on the behaviour of the parasitic Hymenopteran Stelis to its host, an Osmia. The eggs of the two are laid at different ends of the cell ; when they have eaten their way through the food to each other, the parasite kills its "host" and lives on it for two days. (*Zool. Anz.*, xv. 41.)

Ferton has two interesting papers on the habits of hymenoptera ; the one on Osmiæ and their remarkable nidification : the other on Pompilidæ and their murderous attacks on spiders. Like all papers which deal with detailed field-observation, it is impossible to present them in a publication of this kind, as their value depends entirely on the details for which we have no space. (*Actes Soc. Linn. Bordeaux* [5], iv. 201.)

In a short description of Coccus cacti (the cochineal insect), **Mayer** shows that the wax secretion of the animal must pass through the layer of chitin, since there are no pores for its emission. He

states that the same is the case in the honey-bee, as the result of his own investigations. The observation is of interest in connection with cases where the products of digestion apparently pass through chitin. (*Mittheil. zool. Sta. Neapel*, x. 505.)

Chatin has studied the formation of the integument in Libellulæ, and is drawn to the conclusion that here—as has been maintained in other cases—the epidermal cells actually transform themselves into chitinous lamellæ, and do not secrete it as an ectoplastic structure. He can even trace the trabecular structure of the protoplasm in the chitin. (*Comptes Rendus*, cxiv. 1135.)

Werner records an "instinctive" habit on the part of Locustidæ, which seems as hard to explain as the formerly reputed habit of scorpions of stinging themselves to death: namely, the habit of many genera to bite off their own legs, not only when kept in captivity, but at the moment of capture. (*Zool. Anz.*, xv. 58.)

Kunckel d'Herculais maintains that the two tints of the locust, rose and yellow, are merely indicative of different ages, not of two varieties as generally supposed. The interest of his observation lies in his conclusions that the change of colour is associated with the histolysis and histogenesis which accompany the moults. The considerable dependence of their colour on the presence of light was also brought out by breeding some in darkness. He attributes the various tints, perhaps on insufficient evidence, to a zooerythrin. (*Comptes Rendus*, cxiv. 240.)

* **W. H. Hudson** records a new case of mimicry from La Plata on the part of a grasshopper (Rhomalea), which resembles a wasp (Pepris). This wasp is, like all its allies, protected by its sting; but it is also furnished with stink glands, which emit a most disagreeable odour. When on the wing the grasshopper becomes the facsimile of the wasp; moreover, when taken in the hand, it has the curious habit of suddenly curling the body round, as a wasp does to sting. The same author has an interesting chapter on dragonfly storms. In the summer and the autumn, thousands of these insects may be seen flying in a north-easterly direction at the extraordinary speed of 70 or 80 miles an hour, evidently in the utmost terror, before the *pampero*, a cold, dry, exceedingly violent wind. (*Naturalist in La Plata*, 127.)

* **W. Bateson** states that the variation in the colour of the cocoons of the Lepidoptera Eriogaster lanestris and Saturnia caspini, is not due, as has been affirmed, to the colour of the substances to which they are attached; but that it probably depends upon the evacuation or retention of a brown fluid by the caterpillars before they spin. (*Trans. Ent. Soc.*, London, 1892, 45.)

Arachnida.

* This author also maintains that the alleged aggressive mimicry of certain species of Bombus (Humble Bees) by the flies known as Volucellæ, is not quite so simple as has been hitherto assumed. For some of these flies are frequently found in the nests of bees or wasps which they do not resemble. (*Nature*, lxvii. 585.)

* About two-thirds of the zoological appendix to **W. L. Distant's** work on the Transvaal is devoted to insects. Many new forms are described, and much of interest is to be found in the notes on the habits, etc., of living individuals. Curiously enough, six species of Coleoptera, seven of Lepidoptera, and three of Orthoptera, are also tolerably common English species. Mr. Distant mentions that the only enemy that the distasteful butterfly, Danais chrysippus, appears to have is the Orthopterous insect, Hemisaga predatoria.

Kishinouye confirms on embryological grounds the conclusion at which Lankester and Bourne arrived on evidence from the adult, that the lateral eyes of spiders are separated, enlarged, and modified eye-elements (ommatidia) of a former compound eye of the ancestral history. (*Zool. Anz.*, xiv. 381.)

In a preliminary note **Strubell** points out that the development of Thelyphonus bears more resemblance to that of Arachnida than to that of Scorpionidea. (*Zool. Anz.*, xv. 87.)

* **W. H. Hudson** has made some interesting notes upon spider-life in La Plata. He states that green-leaved bushes are frequented by green Epeiras, and in connection with the well-known habit of many members of this tribe, of dropping to the ground from their webs when alarmed, he has noticed that these spiders fall at the same rate as green leaves. Other Epeiras, on the contrary, which are of a dull yellow colour, resembling dead leaves in hue, fall less rapidly than the green ones and at about the same rate as a withered leaf. Of a species of Tetragnatha, which abounds on the pampas and is found in bushes overhanging streams, he mentions that the long pair of legs are exceedingly thin throughout the greater part of their length, but are flattened and expanded at the extremity like an oar. When, as not unfrequently happens, one of these spiders falls into the stream, the function of these curious appendages becomes manifest, for the creature rapidly rows itself to land with them. (*Naturalist in La Plata*, 182.)

* **P. Gaubert**, in an exhaustive paper on some points in the structure of the Arachnida, describes minutely certain cutaneous organs, termed lyriform, which are found in most of the orders of

this class. By an ingenious experiment he has shown that the function of these organs is probably to enable spiders, and by analogy their allies, to appreciate changes of temperature. He placed a number of examples of a species of Lycosa in a bottle, after first covering with varnish the lyriform organs of some of them. The bottle was then placed in warm water, and those spiders that had been left untouched quickly showed by their behaviour that they perceived the increase in the warmth more quickly than those in which the organs had been smeared over. (*Ann. Sci. Nat. Zool.*, xiii. 90.)

* **Michael** has written an interesting paper on the association of Gamasidæ (Mites) with ants. He states that species of Gamasidæ which are found in ants' nests are not usually found elsewhere. The two kinds of animals live on friendly terms; the ants even appear to protect the others, and the latter do not seemingly injure the ants or their young. The object of this strange association is unknown. (*Proc. Zool. Soc.*, 1892, 638.)

Mollusca.

De Villepoix has made some simple experiments with regard to the formation of lime crystals in albuminous fluids, with a view to ascertaining the conditions under which the shells of molluscs are secreted. He regards the conchiolin as the only part of the shell formed directly by the secretory activity of the mantle, the calcareous parts simply crystallising out from the mucus. (*Mem. Soc. Biol.* [9], iv. 35.)

Pruvot has published an interesting note on the embryology of a Proneomenia. It agrees with his previous description of that of Dondersia, and shows more resemblance to the development of a lower annelid, *e.g.*, a leech, than to that of Mollusca. He compares it further in some points to the pilidium larva of Nemertines. (*Comptes Rendus*, cxiv. 1211.)

Korschelt investigated the development of Dreissena with the view of ascertaining the character of the larva. As he expected, it is a free swimming larva, closely resembling that of the oyster and other marine lamellibranchs, but different from the highly modified larvæ of the Unionidæ, etc. The retention of this larva he attributes to the recent date at which Dreissena has migrated from the sea. (*Sitzungsber. Nat. Freunde Berlin.*, 1891, 131.)

Von Erlanger has studied the renal organs in Prosobranchs, and concludes that Trochus, Turbo, and Haliotis have only a left renopericardial opening, while five others, including Patella (in which it was for the first time described), have none. He infers that the only remaining kidney of most Prosobranchs is the original

left kidney of the primitive pair. He discusses also the relations of the kidney in other forms. (*Quart. Journ. Micr. Sci.*, xxxiii. 587.)

Lacaze Duthiers has placed on record (*Arch. Zool. exp. gén.* (2), x. 37) some very interesting observations on an Argonauta living in the aquarium at Banyuls. When first placed in the tank it had abandoned its shell; it soon resumed this, and took up the position which it permanently maintained till its death. This was by no means the conventional and poetical position familiar in popular text books, with the mouth of the shell above water, and the arms expanded to serve as sails; the mouth of the shell is directed forward, the arms are turned backwards so as to expose the mouth, and all of them are tucked into the shell with the exception of the two posterior. In this position the animal floats, with only a small portion of the shell appearing above the surface of the water. In swimming by the usual contraction of the pallial sac the arms are not allowed to swing forwards, as is always the case in Octopus, Eledone, etc. They were never used for walking, nor were the two posterior veligerous arms used either for sailing or swimming. Small fish made to touch the suckers of an arm, were passed down it, and into the mouth.

Joubin has an interesting paper on the often-discussed chromatophores of Cephalopoda (*Arch. Zool. exp. gén.* [2], x. 277). They arise from the ectodermal invagination of a large cell; this becomes cut off from the ectoderm, and surrounded by mesoderm cells and a connective tissue capsule. These mesoderm cells elongate into muscle fibres, which have the power of moving the whole chromatophore, but take no part in its expansion. Later in life they lose their contractility altogether; the changes of colour are due to the movement of the protoplasm of the chromatic cells, combined with the effects given by iridiocytes.

On the other hand, **Phisalix**, approaching the matter from the physiological side, concludes that the expansion of the chromatophore is dependent purely on the radial muscles. (*Comptes Rendus*, cxiii. 510.)

Hemichordata.

T. H. Morgan has re-studied some points in the anatomy of Tornaria, and pronounces in favour of the double alliance of Balanoglossus to Echinoderms and Vertebrates, on the grounds of the similarity between Tornaria and Auricularia, which he discusses in detail. (*Journ. Morph.*, v. 407.)

Fowler shows that in the arrangement of the five body cavities and notochord, Rhabdopleura agrees with the Hemichordata. (*Proc. Roy. Soc.*, lii. 132.)

Tunicata.

Development of the nervous system.—The derivation of the nervous system in asexually budded Ascidians has in some cases been doubtfully assigned to the mesoderm, a violation of what is in all probability a general law, that it arises from the ectoderm. In his third paper on the embryonal development of Pyrosoma, **Salensky** shows that here at least it arises from ectoderm, both in the case of the cyathozooid, the rudimentary sexually-produced zooids, and in that of the ascidiozooids, the complete zooids which are budded from the cyathozooid. The characteristic ciliated pit of the cyathozooid is derived from this ectodermal nerve-layer; in the ascidiozooids two such structures are formed, one a provisional structure, from the nerve-layer, the other apparently from the endodermal intestinal cavity. (*Cf.* Pizon *infra.*) He describes in the ascidiozooids two tentacle-like sense-organs resembling those described by Bolles Lee last year. ("Year-Book," 1891, p. 354.) The remarkable larval organ termed by Huxley the diapharyngeal band, a tube connecting the upper and lower blood sinus, running diagonally from nervous system to endostyle, is regarded by Salensky as homologous with, and probably indicative of the phylogenetic history of the tubular gill of Salpidae, a structure which is otherwise without parallel among Ascidians. In summing the results of this and the previous paper (*loc. cit.*), he concludes that the possession of a single ovum in the ovary of Salpa and Pyrosoma is derived from the "polyovular" [*sic*] condition of other Ascidians; but the kalymmocytes and follicle cells are to be regarded as abortive ova. The paper concludes by a criticism of Seeliger's theory of the origin of alternations of generations in Ascidians. The author is himself of opinion, as before, that metagenesis was rendered possible in the first instance by the capacity of the same individual to reproduce both sexually and asexually as in the Synascidians, that the "*amme*" or asexual generation was the result of premature budding before sexual maturity was reached, that the essentially sexual generation was at first capable also of budding (Pyrosoma), and finally lost this power (Salpa). (*Zool. Jahrbücher*, v. 1.)

Pizon, after a comparative study of the development of the ciliated pit in many Ascidians, concludes that it develops from endoderm, and cannot therefore be homologous with the hypophysis cerebri as suggested by Van Beneden and Julin. (*Comptes Rendus*, cxiv. 237.)

On the other hand, **Hjort** working on Botryllus, and **Willey** on Ciona and Clavelina, alike conclude that hypophysis and

permanent cerebral ganglion have a common ectodermal origin, the former opening into the stomodaeum as a wide tube, on the roof of which the latter is formed as a thickening. (*Zool. Anz.*, xv. 328, 332.)

Development of the vertebrate eye.—**Bütschli** publishes an interesting preliminary note on the eyes of Salpae. In its simplest form the salpid eye is of the usual invertebrate type, seated on the brain as a cone of vertical retinal cells flanked by pigment cells. The more complicated eye is tripartite, and its arrangement is of considerable interest. The central part of the three is of the simple character just described; in the lateral parts, however, the retinal cells are horizontal, the nerve-fibres proximal; the pigment cells being still distal, *i.e.*, lateral, a kind of inverted or vertebrate eye is the result. The author naturally draws a comparison between these three, and the three eyes of Vertebrata, and points out that if the former have any ancestral relation to the latter, an explanation of the choroidal fissure is furnished by the position of the optic nerve. (*Zool. Anz.*, xv. 349.)

A new Ascidian.—**Korotneff** describes under the name of Dolchinia a remarkable new Ascidian from Naples, a close ally of the interesting forms Doliolum and Anchinia. The specimens consisted of a gelatinous tube living and even moving, on which were irregularly implanted by "pseudopodia" large numbers of the zooids proper. The tube he regards as the dorsal appendage of a hitherto unknown "nurse" form, on to which the buds have wandered as in Doliolum. Of the buds themselves two kinds were recognisable, the one a fully-developed asexual zooid, corresponding both to the "spoon-buds" and "nutritive-buds" of Doliolum; the other, the sexual zooid, produced by gemmation from the former. Of the three genera, the life-history appears to be least complicated in Dolchinia, most so in Anchinia; the degree of complication being probably of phylogenetic value. (*Mitth. zool. Sta. Neapel*, x. 187.)

VERTEBRATA.

Development of structures.

In the seventeenth paper of the studies on vertebrates, **Dohrn** traces the histogenesis of certain nerves, and shows that the whole nerve—stem, branches, and twigs—splits off from ectoderm; further, that the ganglion cells take no part in the formation of nerve-fibres, but that their so-called prolongations are only in secondary contact with them. He has also traced the development

of nerve-fibres from ectoderm cells, and watched them arrange themselves in a string; the axis cylinder is deposited in the centre of the cell, the plasma gives rise to the medullary sheath, the nucleus of the cell becomes the Schwann's nucleus of the fibre. (*Mitth. zool. Sta. Neapel*, x. 255.)

Dohrn, however, practically withdraws this (*Anat. Anz.*, 1892, 12), but it is maintained by **Beard**, in the same journal. **Von Kolliker**, as against both of them, maintains a series of theses to show that all nerve-fibres are outgrowths of nerve-cells in accordance with the older view. (*Verh. Anat. Ges.*, vii. 76.)

Ayers publishes an exhaustive paper on the Vertebrate ear. He regards it as a complex system of superficial sense organs and "mucous" canals, such as occur in the lateral line, which has sunk below the surface of the head. The auditory nerve is not of segmental value: nerves vii. and ix., the nerves of the permanently superficial sense organs in this region, participate in the nerve supply of the deeper ones. (*Journ. Morph.*, vi. 1.)

Rabl, than whom no one is more qualified to speak on the matter, after summarising at great length the views of various authors on the subject, from Huxley's Hunterian Lectures of 1869 to the most recent memoirs, concludes that neither from the mesodermal nor from the nervous standpoints is it possible to arrive at a clear appreciation of the metamerisation of the Vertebrate head, the study of which has absorbed so many workers, especially of late years. (*Verh. anat. Ges.*, vii. 104.)

Assheton has some interesting observations on the development of the optic nerve in Vertebrates. He shows that its fibres arise along the posterior border of the optic stalk completely outside it, from nerve-cells of the retina. His views of the choroidal fissure are in a curious unconscious agreement with those quoted above from Bütschli (p. 360) relative to the lateral eyes of some Salps. (*Quart. Journ. Micr. Sci.*, xxxiv. 85.)

Retzius describes and figures not less than nine variations in the posterior termination of the nerve-cord of Amphioxus; of these all but one are swollen and contain a large ventricle, and one exhibits, in addition, a prolongation running downwards over the notochord, which appears to represent the traces of the embryonic neurenteric canal. (*Biol. För. Förhdl.*, iv. 10.)

Sedgwick, in writing of elasmobranch development, records some important conclusions. He shows that the blastopore is a much larger structure than has been supposed, not only including the generally accepted part which becomes converted into the neurenteric canal, but also extending as an S-shaped streak under the tail fold and backwards to the yolk-blastopore, which is really

a part of it. On his view that the first formed embryonic rim represented the anterior end of the embryo, the blastopore does at one time or another perforate the whole length of the medullary plate. Read in connection with Hertwig's paper (see below), his account of the formation of the blastopore is extremely suggestive. The mouth arises as a *longitudinal* slit, and though in no vertebrate has the mouth been actually traced into connection with the blastopore, he adds this to the evidence which he has previously brought forward for the view that it is derived from the anterior part of the blastopore. It is noteworthy, in view of the numerous attempts to discover from different sides the "primitive" segmentation of the vertebrate head, that he points out that if the number of primitive cranial somites in any given region of the head does really differ in closely allied genera in the manner indicated by the divergent observations of Dohrn, Van Wijhe, and himself, the supposed indications of segmentation in the adult have little value as "primitive" tests. He finds in Elasmobranchs as in Peripatus a continuity of the cells, a pale protoplasmic network extending inwards from the nucleated protoplasm of the various surfaces; and inclines to Hensen's view of the ontogeny of nerve-fibres, namely, that they are persistent remains of these primitive connections between the incompletely separated cells of the ovum. (*Quart. Jour. Micr. Sci.*, xxxiii. 559.)

In discussing the systematic value of the auditory organs of Teleostei, **Von Jhering** complains that the Darwinian theory is utterly inadequate to explain the enormous variations exhibited by the otoliths both in size and in weight relative to body-weight, when their alterations in form are sufficiently constant to be used for systematic classification. He neglects, however, altogether the other point of view from which such variations may be regarded, viz., that it is just these variations which constitute the material with which natural selection works; were they less marked its operations would be infinitely slower. (*Zeit. wiss. Zool.*, lii. 477.)

O. Hertwig finds that in over-ripe eggs of Rana a segmentation at the animal pole may occur, while the vegetative pole remains as an unsegmented yolk-mass—the segmentation thus resembling that of a bird's egg, telolecithal and mesoblastic. The author attributes this result to polyspermy, the entrance of several spermatozoa into the ovum and their fusion with its nucleus. More important are abnormalities in the gastrulation process, which fall under three groups. The first group produces a larva, which may be best conceived by imagining that a normal larva at

the stage when the medullary groove should be still open is split along the whole length of the medullary plate, so as to let the yolk protrude in a hump. It has mesoderm and protovertebrae, and a notochord on *each* side under one half of the medullary plate. As these medullary halves are connected at each end of the split, there is really a medullary *ring* encircling a widely-open blastopore. Hertwig regards this as an original condition, explaining the relation of blastopore to nervous system; and it is interesting in the light of the views of Sedgwick and others as to the primitive relations of the blastopore. Three other groups of cases contain older larvæ with a similar widely-open blastopore in the dorsal or the anal region. Hertwig gives in his adhesion to the "concrescence" theory of the vertebrate embryo first laid down by His, the idea of a double growth of two symmetrical parts. The annular condition of the nervous system, the annulus broken only at the position of the anus, he regards as primitive. The blastopore is a cavity, primarily formed by invagination, giving origin to alimentary canal and body cavity (enterocœle), surrounded by this nerve-ring, which gradually closes along the whole length of the embryo except at the anus; along its line of suture is formed the notochord. As regards the blastopore in Amniota, he retains the old idea that it is represented by the primitive groove. The blastopore appears in teratology as "spina bifida." The paper is of great length, and only a few of the author's (apparently) more striking conclusions are here given. Against his idea that these monstrosities are the result of polyspermy, may be urged the observations of Oppel ("Year-Book" for 1891, 338), and of Rückert (see above, p. 345). (*Arch. mikr. Anat.*, xxxix. 353.)

Jordan and **Eycleshymer** record briefly a number of variations which may occur in the early segmentation of the Frog's ovum, which appear to point to much the same conclusions as those of **Driesch**. (*Anat. Anz.*, vii. 622.)

MacBride, in studying the development of the oviduct in the frog, finds that it arises primarily opposite the third funnel of the head-kidney, and in connection with, perhaps by proliferation of, a strip of peritoneum along its whole length, and is quite independent of the Wolffian duct. He believes, as others lately have concluded, that the oviduct is a product of the peritoneum, and bears no relation to the Wolffian duct. (*Quart. Jour. Micr. Sci.*, xxxiii. 273.)

Against Knauthe's observations, recorded last year ("Year-Book" for 1891, 358), **Müller-Erzbach** recapitulates the conclusions which he published in 1872, showing that frogs can be absolutely

frozen hard ($-6°$ to $-8{\cdot}7°$ C.) for five hours and can yet recover. (*Zool. Anz.*, xiv. 383.)

Bataillon has made some physiological researches on the metamorphosis of the Anura. At the commencement of the process the elimination of carbon dioxide is reduced and it accumulates in the blood; during the metamorphosis an enormous quantity of sugar is produced in the blood without there being any trace of glycogen in the liver. These two points remind the author of the glykaemia of asphyxiation, and he even defines the metamorphosis as an assemblage of the phenomena of asphyxiation. (*Ann. Univ. Lyon.*, ii. 1.)

Robinson publishes an important contribution to the early developmental history of Mammalia, especially as regards the "inversion" of the layers. He deals with rat and mouse as being easily procured and manipulated. The segmentation produces an embryo with large segmentation cavity, the distal floor of which is thick and destined to form the hypoblast, and of the thin proximal roof a portion gives rise to the embryonic epiblast. The archenteron (yolk sac) is excavated in this hypoblastic floor; part of the epiblastic roof is invaginated as a hollow vesicle into the segmentation cavity, which it obliterates, and is cut off from the remaining epiblast; it finally pushes the proximal wall of the archenteron before it so as to be nearly surrounded by it: the external layer of epiblast grows down over, but never completely covers, the hypoblast. The solid mass of epiblast above (proximal to) the epiblastic vesicle is the trophoblast, and at the point where these two regions adjoin, viz., the cephalic end of the embryo, the mesoblast makes its first appearance.—The paper contains interesting detailed comparisons between the forms studied and other Mammalia. (*Quart. Journ. Micr. Sci.*, xxxiii. 369.)

Haycraft has worked at the development of the Chelonian carapace, and concludes that the much-discussed costal plates are truly rib-expansions, ossification spreading outwards from the rib. (*Tr. Roy. Soc. Edin.*, xxxvi. 335.)

Robertson believes that the long process of an odontoblast becomes continuous with the axis cylinder of a nerve-fibre, but his figures can hardly be said to place the point beyond the reach of doubt. In investigating the growth of teeth, the author concludes that increase in length occurs by the addition of new dentine below; increase in diameter by dilatation of the basal formative ring of odontoblasts, by deposit of fresh dentine on the inner surface, and to a small extent by interstitial growth. (*Tr. Roy. Soc. Edin.*, xxxvi. 321.)

Blanc records a remarkable case of hermaphroditism in a goat

The animal was a complete male of 6–7 months, with the addition of a well-developed uterus, etc.; the upper end of the fallopian tube was in contact with the epididymis. (*Ann. Soc. Linn. Lyon.*, xxxviii. 59.).

Duval concludes this year his long series of papers on the placenta of Rodents. His work has led him to the belief, which appears likely to be justified in other groups than Rodents, that the placenta is an entirely fresh formation produced exclusively by growth of the embryonic ectoderm. (*Jour. Anat. Physiol.*, [Paris], xxviii. 333.)

Mammals.*

An important addition to our knowledge of the distribution of the mammals of North America is made by **C. H. Merriam**, who shows that the continent can be divided into four parallel zones —the Boreal, the Transition, the Sonoran, and the Tropical—each distinguished by a more or less characteristic assemblage of mammals. It is considered that the glacial period has been a very important factor in distribution; the author suggesting that even llamas may have been originally northern forms driven as far south as the Andes by the cold. (*Proc. Biol. Soc. Washington*, vii. 1—64.)

The individual variations of teeth among mammals are discussed by **W. Bateson**, who is of opinion that the accepted views of dental homology are not altogether tenable. He clearly proves, from the instance of a seal, that an originally single tooth may by division give rise to two distinct teeth. (*Proc. Zool. Soc.*, 1892, 102—115.)

The subject of the origin of mammalian teeth continues to occupy the investigations of **W. Kukenthäl**, who is now especially studying those of whales and marsupials. His conclusions indicate that both groups originally had a milk and a permanent series; and that in the marsupials it is the latter which mainly persists. (*Jenish Zeitschr. Nat.*, xxv. 449, and *Biol. Centralbl.*, xiii. 400.)

C. Röse also deals with the same subject, showing that there are rudiments of teeth in fœtal Pangolins—a group in which teeth have hitherto been considered entirely wanting. (*Biol. Centralbl.*, xii. 624, and *Anat. Anz.*, vii. 618.)

Among faunistic works **O. Thomas** describes several new mammals recently obtained from the East Indian Archipelago; the most interesting of these being a second species of the

* The following sections are by R. Lydekker.

Viverrine genus Hemigale, previously known only by H. hardwickei. (*Ann. Mag. Nat. Hist.* [6], ix. 250, and *Proc. Zool. Soc.*, 1892, 221, pls. xviii., xix.)

An important memoir on the mammals of East Africa is contributed by **F. W. True**, with a complete list of all the known species. Some new rodents are described, and figures given of the recently discovered fringe-eared Oryx, and of a rare antelope of the genus Cephalophus. (*Proc. U. S. Nat. Mus.*, xv. 445, pls. lxxv.—lxxx.)

F. E. Beddard contrasts the muscular systems of the two species of Chimpanzee, with remarks on their distinctive characters, and also some observations on the species of Orangs. (*Proc. Zool. Soc.*, 1892, 118.)

An especial feature of the year has been the number of new species of monkeys described—viz., a Gibbon from Hainan, three species of Semnopithecus, and two of Cercopithecus; the two latter from East Africa.

The bats of Lagoa Santa, Brazil, are described by **H. Winge** in an elaborate monograph, unfortunately in Danish. The fossil cave-forms are compared with those still living, and a new scheme of classification, together with certain emendations in nomenclature propounded. (*Ex Mus. Lund.*, iii., 65 pp., 2 pls.)

Among the Insectivores, **O. Thomas** calls attention to the affinities of the little-known hedgehog-like genus Echinops; while he also shows that the allied Centetes, of Madagascar, exhibits, when fully adult, the marsupial feature of having four true molar teeth. It is further suggested that the affinity between the latter animal and the West Indian genus Solenodon is much less intimate than has been hitherto supposed. (*Proc. Zool. Soc.*, 1892, 500.)

The life-history of the Canadian beaver, together with the history of its discovery, its importance in commerce, and its impending extermination, are carefully described by **H. T. Martin** in "Castorologia, the History and Traditions of the Canadian Beaver" (London and Montreal, 1892, 8vo, 238 pp., illustrated).

The mole-rat (Spalax typhlus), hitherto known only from eastern Europe and Asia, is recorded by **J. Anderson**, together with observations on its habits, from Egypt. (*Proc. Zool. Soc.*, 1892, 472.)

The presence of a rudimental tooth in front of each jaw in the rabbit is confirmed by **Fruend**, by whom it is regarded as a reduced milk-tooth. (*Arch. Mikr. Anat.*, xxix. 525, 2 pls.)

A revision of the whole group of Hyraces is made by **O. Thomas**, who concludes that both the ordinary terrestrial forms and the

arboreal species (Dendrohyrax) must be included in a single genus—Procavia. Altogether fourteen species are recognised. (*Proc. Zool. Soc.*, 1892, 50, pl. iii.)

That existing horses occasionally display polydactylism is fully proved in a paper by **O. C. Marsh**, where several examples with supernumerary digits are figured. It is inferred that these extra toes indicate reversion to an ancestral type. (*Amer. Jour. Science* [3], xliii. 339.)

The alleged existence of horses in La Plata at the time of the discovery of America is controverted by **F. L. Trouessart.** (*Science*, xx. 127.)

During the year several new species of African antelopes have been described; the most notable of these being two hartebeests, Bubalis swaynei from Somaliland (*Proc. Zool. Soc.*, 1892, 98), and B. jacksoni from East Africa (*Ann. Mag. Nat. Hist.* [6], x. 386); the hairy-eared Oryx—Oryx callotis from East Africa (*Proc. Zool. Soc.*, 1892, 195); and Cephalophus jentinki from Liberia (*ibid.*, 417).

The value of the antlers in the classification of the deer is discussed by **A. G. Cameron**, who proves that these appendages of the deer of the New World cannot be homologised with those of Old World types. (*Field*, lxxix. 625, 741, 860.)

W. T. Blanford adduces evidence to show that there are no really wild camels in Central Asia. (*Proc. Zool. Soc.*, 1892, 370.)

The discovery of a dolphin believed to be herbivorous in the Camerun district is recorded by **W. Kükenthal**, who refers it to a new species of the genus Sotalia. (*Zool. Jahrb.* vi. 442, 446.)

Edentates are remarkable for the absence of enamel in their teeth, but it is shown by **E. Ballowitz** that this is due to degradation; an enamel-organ being present in the embryos of certain armadillos. (*Arch. Mikr. Anat.*, xl. 133, pls. vi., vii.)

That the Marsupial mole (Notoryctes typhlops), first fully described in 1891, is an undoubted Polyprotodont Marsupial, is proved by a dissection undertaken by **H. Gadow** (*Proc. Zool. Soc.*, 1892, 361.)

The large Mammals of South Africa, together with the game-birds, are described by **J. A. Nicolls** and **W. Eglington**, with figures of the heads of many, and notes on their distribution and habits. (*The Sportsman in South Africa,* London, 1892, 8vo, 147 pp. and pls.)

Birds.

In this extensive subject all that can be done in the space which can be allotted to the subject in this volume is to notice a

few of the more important works and papers which have appeared during the year.

The classification of birds receives attention from **H. Gadow,** who propounds a scheme differing in some respects from any of those hitherto published. They are divided into the sub-classes Archornithes and Neornithes; the first containing only Archæopteryx, and the latter all the rest. (*Proc. Zool. Soc.*, 1892, 229.)

The most important ornithological works of the year are the xvith and xviith vols. of the "British Museum Catalogue of Birds," both of these treating of the Picariæ. Vol. xvi., by **O. Salvin** and **E. Hartert,** includes the Upupæ, the Trochili, and part of the Coraciæ; while vol. xvii., by **R. B. Sharpe** and **W. R. O. Grant,** is devoted to the remaining Coraciæ and the Halcyones.

"The Migration of Birds" forms the title of a work by **C. Dixon,** in which this subject is treated from all its aspects. (London, 1892, 8vo, pp. 300.)

A. B. Meyer and **F. Helm** continue their observations on the times of arrival, date of nesting, etc., of the birds of Saxony, with the full distribution of the various species. (vi. *Jahreshbericht des Ornithol. Beobachtungstationen im Königreiche Sachsen,* Berlin, 1892, 4to, 135 pp.)

The periods occupied by different birds in nidification receive attention from **W. Evans.** (*Ibis.* [6], v. 55.)

The breeding-habits of the cuckoo and other parasitic birds are treated of by **E. Baldamus.** ("Das Leben der europaischen Kuckuke," Berlin, 1892, 224 pp.)

British birds, as a whole, are figured and made easy of identification by **W. J. Gordon** ("Our Country's Birds," London, 1892, 12mo, 152 pp. and plates). Those of the North of England are described by **H. A. Macpherson** ("Fauna of Lakeland," Edinburgh, 1892, 8vo, 552 pp., illustrated); those of Gloucester by **C. A. Witchell** and **W. B. Strugnell** ("Fauna and Flora of Gloucestershire," Stroud, 1892, 8vo, 301 pp., illustrated); those of Devonshire by **W. S. M. Durban** and **M. A. Matthew** ("Birds of Devon," London, 1892, 8vo, 459 pp., illustrated); those of Lancashire by **H. Saunders** (Mitchell's "Birds of Lancashire," Second Edition, London, 1892, 8vo, 271 pp., illustrated); and those of part of North Britain by **J. A. Harvie-Brown** and **T. E. Buckley** ("A Vertebrate Fauna of Argyll and the Inner Hebrides," Edinburgh, 1892, 8vo, 252 pp., illustrated).

R. Collett has an important memoir on the birds of Arctic Norway. ("Address to Ornithological Congress" in *Report of the Congress,* Budapest, 1892, 4to.)

The distribution and habits of the birds of the Moscow district are described by **T. Lorenz.** (*Bull. Soc. Mosc.*, 1892, 263.)

T. Salvadori records twenty-three species from Enyaro, near Sumatra, of which eight are new (*Ann. Mur. Genoa* [2], xii. 123); while **R. B. Sharpe** describes a number of species recently obtained from Borneo. (*Ibis.* [6], v. 430, plates.)

Turning to Africa, **R. B. Sharpe** gives an account of the birds of Uganda, many of which are new (*Ibid.*, 152, 299, 534, pls. iv., v.); **R. Reichenow** describes new forms from the Nyanza (*Journ. f. Ornithol.*, 1892, 1) and the Cameroons (*Ibid.*, 177); while **W. L. Distant** has notes on the habits of those of the Transvaal ("A Naturalist in the Transvaal," London, 1892, 8vo, 277 pp.).

C. Bendire's account of the life-histories of North American birds treats of the habits, eggs, etc., of the game-birds, pigeons, owls, and birds of prey. (*Smithson. Contrib. Knowl.*, xxviii., 414 pp., 12 plates.)

The description of the birds of Central America is continued by **F. du C. Godman** and **O. Salvin.** (*Biologia Centrali-Americana*, xcvii.–civ., plates, 4to, London, 1892.)

In South American birds, **J. C. Kerr** describes those of the Lower Pilcomuyo—a tributary of the Rio Paraguay—adding twenty-nine species to the Argentine fauna (*Ibis* [6], v. 120, pl. iii.); **W. H. Hudson** has notes on the habits of those of the Argentine ("The Naturalist in La Plata," London, 1892, 8vo); **E. Whymper** shows that the accepted view of the habits of the Condor is incorrect ("Travels amongst the Great Andes," 1892, 8vo); and **R. Ridgway** gives an account of all the humming-birds. (*Rep. U.S. Nat. Mus.* for 1890, 253 [1892].)

S. B. Wilson and **A. H. Evan** continue their monograph of the birds of the Sandwich Islands. ("Aves Hawaiiensis," iii., London, 1892, 4to.)

R. W. Shufeldt's monograph of the osteology of the Arctic and Subarctic water-birds is also continued. (*Journ. Anat. Phys.*, xxv., 509 *et seq.*)

Reptiles, amphibians, and fishes.

In all these three classes the work of the year appears to be mainly of a descriptive or faunistic nature, and offers little of general interest.

E. D. Cope's description of the osteology of the Lizards is, however, a contribution to a branch of the science which has been too much neglected. (*Proc. Amer. Phil. Soc.*, xxx. 185.)

The remarkable habit of ejecting blood from their eyes,

possessed by the American horned toads (*Phrynosoma*), is fully described by **O. P. Hay**, and is believed to be for the purpose of defence. (*Proc. U.S. Nat. Mus.*, xv. 375.)

The structure, form, and development of the tadpoles of the various European Batrachians form the subject of a paper by **G. A. Boulenger**, covering almost entirely new ground. (*Proc. Zool. Soc.* for 1891, 593, pls. xlv.–xlvii., 1892.)

An interesting note on the habits of the Australian lung-fish is given by **W. B. Spenser**, in which it is suggested that the fish may respire by its lung when the rivers are in flood and their waters foul through mud. (*Proc. Roy. Soc. Vict.*, iv. 82.)

A. Smith Woodward shows that certain herrings inhabiting the rivers of New South Wales are generically identical with the Tertiary and Cretaceous fishes described as *Diplomystus*, and hitherto regarded as belonging to an extinct genus. (*Ann. Mag. Nat. Hist.* [6], x. 413.)

ANIMAL PHYSIOLOGY AND PATHOLOGY.

BY C. S. SHERRINGTON, M.A., M.D.

General physiology.

Verworn has now set himself the task of experimentally investigating the functions of the nucleus of the animal cell. The method he used is one which has already been employed by him, the only one which gives exact and thoroughly trustworthy results in operative physiology when it is a question of investigating the function of an organ.

Protozoa were the exclusive objects of the research. With scissors they were so divided that their bodies were cut into a piece with a nucleus and a piece without a nucleus. The latter form the chief object of the investigation. The animals which were employed for observation were certain Radiolaria, and a particular Infusorium. The representatives of the Radiolaria exhibit especially favourable facilities as objects of research; their bodies, as is well known, consist of Ectoplasm and Endoplasm, and conceal the so-called central capsule. Outside this the plasma is differentiated into a sheet of vacuoles and into a sheet of slime, while the nucleus is enclosed in the plasm contained in the capsule. By cutting or pricking into the sheet of slime and sheet of vacuoles, certain pieces are found which contain a nucleus, and other pieces containing no nucleus. Observation of the parts without either capsule or nucleus shows that after recovery from

the operation they again soon take a normal individual form, pushing out pseudopodia, by means of which they even bring themselves food, though they are not able to digest it. The final fate of such bits is always degeneration, which, however, can be postponed by introducing a central capsule from without. On the other hand, isolated central capsules regenerate into perfect animals that do not in any way differ from the normal. The regeneration occurs in the following manner:—Pseudopodia are first extended through the pores of the central capsule, then the outside wrapper or mucous layer, and at the very last the layer containing vacuoles, by means of which they become again enabled to float upon the surface of the water.

The author's account of the formation of vacuoles is of much interest. They originate by little particles of water passing into the interior of the mucous layer. Since, however, the salts which exist in sea-water are not taken up with the water containing them, the otherwise specifically heavier animals can float in sea water. The experiments further show that a central capsule without a nucleus, just like the wrapper or layer outside a capsule, cannot apparently maintain a normal condition, but likewise dies. This same thing is ascertained for portions of the intra-capsular part which has no nucleus. The experiments exemplify the correctness of the broad rule, that the degeneration phenomena of masses of protoplasm without a nucleus are perfectly identical with those in an intact or normal animal; and that plasma which is at the point of death or decay is preserved through mixing (before degeneration) with fresh plasma which contains a nucleus. Verworn does not rest this fact merely on experiments made upon Radiolaria—*e.g.*, on Thalassicolla, but also on Foraminifera, as Orbitolites. He also further studies very thoroughly in the latter the formation of pseudopodia, and what effect stimulation had upon them. He also studies the respiration of those portions of Protista which were without a nucleus. The result is that the parts without a nucleus, as much as those which contain a nucleus, require oxygen for their sustenance, and that without it they die in a very short time. In the theoretical part of the work the author gives a short objective survey of the views of earlier authors on the significance of the nuclei in cells, before he undertakes, on the basis of the above facts, to put forward his own view, which not only entirely agrees with the facts but also is the natural outcome from them.

Out of the knowledge gained we see that neither the nucleus by itself alone, nor the plasma without a nucleus, can continue to live or support themselves. From this it is clear that the nucleus

must always play an extremely important part in the activity of the cell, not merely because this is shown by the morphological works of Korschelt and Haberlandt, but also by the trustworthy experiments above alluded to. For the plasma deprived of a nucleus shows a falling off of assimilation and dissimilation; on the other hand, by introducing a nucleus into plasma which previously contained no nucleus it can be excited to normal activity. It is a question of correlation between cell nucleus and cell plasma: both are concerned in the metabolism of the whole cell. The author seeks to make this knowledge clear through a scheme which we are already acquainted with from his psycho-physiological studies of Protista. The influence on the activity of the nucleus rests on its correlation to the metabolism of the protoplasm. (*Pflüger's Arch.*, li. 1.)

E. Waymouth Reid has continued his experiments on the process of diffusion on the skin of frogs with a new apparatus, and has arrived at the following results:—That in the skin of frogs there is a true absorption process which is brought about after complete exclusion of osmotic influences. It appears that the still living skin taken from the freshly killed animal allows fluid to pass from the outer to the inner surface; this is a specific action of the living tissue. Possible mistakes, owing to capillary action, endosmosis, and such like, have been, as shown by special experiments, completely excluded by the author. (*Brit. Med. Jour.*, 13th February, 1892.)

The blood and circulation.

Kolossow has examined the structure of the endothelial cells of the blood and lymph-vessels by means of a method which serves at once to fix and stain preparations required for inspection under the microscope. The author examines the endothelium of numerous representatives of all classes of vertebrate animals, and shows that the cells are of an extremely complicated character.

They consist of a protoplasmic part, which contains an eccentric nucleus; this part unites with the corresponding portions of neighbouring cells. Extremely thin "surface sheets" cover the free surface of the protoplasmic part, but in such a manner as to make the latter extend beyond the edges and form a continuous whole. The "surface sheets" meet one another at their edges, and are kept together at their under surfaces by fine cemented threads, which spring from the protoplasmic part of one and pass directly into those of neighbouring cells. The deeper portions of one protoplasmic part spread out one from the other, consequently the uniting protoplasmic processes are of some length. The individual cell, therefore, is in the form of a much

truncated flattened pyramid, the base of which is formed by the "surface sheet." The intermediate spaces between the cells are narrowest at the surface and widen towards their deeper parts, so that intercellular canals are left between them.

When several "surface sheets" meet at their corners the protoplasmic bridges are almost wanting. The protoplasma is contractile; by stimulation, caused by irritation of the protoplasmic part, the cells become thickened, the processes (bridges) even give way, the intercellular canals become wider, the "surface sheets" follow these movements passively, become bulged and detached from each other at the corners, and so leave openings.

From these structural relations, and the fact that the intercellular canals are filled with a serous fluid, which has a reducing effect on the nitrate of silver, the different appearances of silver preparations are easily explained. The top surface of the "surface sheets" is covered with very tender, short, little hairs, which protrude from the surface like thick points. With some amphibia they are rudimentary, with others they do not exist at all; this is the case with fish and with sauropsida.

The groups of protoplasmic, cubical cells which exist in certain places in the endothelium, the so-called germinal cells, are merely modified endothelial cells. They are also found in amphibia and reptiles; they, however, do not exist in birds and fish—for that reason they can have no importance as germinal centres. To this place the germinal epithelium of ovary belongs; in mammals also it consists of the "surface sheets," with little hairs, and of protoplasmic parts, which are among themselves united, and also with the endothelium by fine, short processes.

The increase of cells, which occurs with inflammation in grown animals, is brought about by mitosis, whereby only the "surface sheets" are completely divided, while the protoplasmic parts remain joined together by their communicating arms, and also a kind of syncytium. Especially prominent is the fact that with all animals the blood and lymph-vessels of the endothelium are destitute of little hairs. From the above observations the author concludes that the endothelium and epithelium cannot be brought into opposition, and that the endothelium is not derived from the ordinary connective tissue cells. Archiblast and Parablast produce genuine epithelium. (*Biolog. Centralbl.*, xii. 87, No. 3, 1892.)

M. Grünbaum and **R. von Braunschweig** have carried on experimental researches on the extirpation of the thymus gland and the regeneration of blood corpuscles. In these researches it is a question of determining by suitable experiments, followed by

microscopical investigation, if, and in what way, the above-named organs take any part in the forming of the blood. Grünbaum induced the regeneration of the blood corpuscles in the following ways:—

(1) By venesection.
(2) By chemical reagents which destroy the blood corpuscles.
(3) By extirpation of the spleen.
(4) By extirpation of the spleen followed by bleeding.

In this way the following results were obtained:—

(1) At each recurrence of increased formation of blood corpuscles the lymphatic glands react by enlargement, and sometimes by flushing.

(2) The enlargement depends on the increase of the individual elements in cortical nodules and medullary cords on the one side, and on an enlargement of all the lymphatic paths on the other hand. The widened lymph paths and peripheral lymph sinus are filled with a lymph which is very rich in blood and blood-corpuscle cells; hence the swollen condition of the lymphatic glands.

(3) The colourless corpuscles arise from lymph cells, which lie free in the meshes of the reticulum, and from the endothelial cells of the reticulum by mitosis. This happens chiefly in the germinal centres, but also in the medullary cords.

(4) In connection with the frequent appearance of mitosis in the lymphatic glands stands the fact that after venesection and extirpation of the spleen the number of colourless corpuscles in the circulating blood is relatively large, and that after bleeding the blood coagulates in a strikingly rapid manner.

(5) After extirpation of the spleen a remarkably large quantity of cells containing blood corpuscles are, as a rule, met with in the lymphatic glands of the lymph paths.

(6) Under certain conditions (after bleeding and extirpation of the spleen) the lymphatic glands take part in the formation of red blood corpuscles in grown animals, by division of nucleated red blood corpuscles which takes place exclusively in the lymph sinus. These nucleated red blood corpuscles probably come from the endothelial cells of the lymph sinus. Whether division by mitosis or by "direct segmentation" occurs remains undecided.

The results from Braunschweig's paper are as follows:—

(1) After the operation for inducing regeneration of the blood corpuscles (bleeding and extirpation of the spleen) the thymus gland shows no enlargement or other change perceptible to the naked eye.

(2) Corresponding to the macroscopical readings, the macro-

scopic examination gives no important increase of cells in the gland.

(3) No substantial importance can be ascribed to the thymus gland for the regeneration of white blood corpuscles during extra-uterine life. (*Inaug-Dissert. Dorpat*, 1892.)

Cushny employs chloroform and ether narcosis in such a manner as to be able to give an exact dose of these anæsthetics. This is done by a tap regulating the quantity of air which is to be allowed to mix with a known quantity of the anæsthetic, and which is also saturated with water before reaching the animal. Artificial respiration is employed in order to make the quantity of gas inhaled independent of irregularities which occur with natural respiration. By these methods it is seen that when air saturated with chloroform is used, the chloroform can kill by affecting the heart before, or simultaneously with, cessation of the respiration. Diluted chloroform (that is, the air containing 55 per cent. or less) generally kills by injuring the respiration, while the heart, although weak, continues to beat. This is the case with the narcosis as usually carried out by the surgeon.

The less the concentration, the slower also the stupor comes on, and so much the less is the heart injured.

While the author in these points does not agree with the Hyderabad Chloroform Commission, he yet agrees with them in thinking that when weak doses are given the blood falls gradually and never suddenly.

The same thing holds good for ether as for chloroform, there being only a quantitative difference, inasmuch as greater concentration can be borne with ether than with chloroform. Air saturated with ether can, however, cause death in a similar way to chloroform, by almost simultaneous injury to the heart and respiration. The heart is, therefore, not indifferent to ether. For a rapid production of anæsthesia, at the most 15 to 20 per cent. of chloroform, and from 37 to 52 per cent. ether should be employed. When once, however, anæsthesia sets in, it is sufficient to keep on with 7·5 to 5 per cent. chloroform, or 19 to 25 per cent. ether. In chloroform narcosis all reflex actions cease before the respiration is paralysed; the first to stop is the eyelid reflex, the next the reflex from the palate, then reflex swallowing and sneezing.

The author finds definitely that chloroform acts directly upon the respiratory centre in the bulb. The space of time elapsing between the disappearance of reflex actions and paralysis of the respiration stands in inverse relation to the concentration of the anæsthetic. The respiratory convulsion which comes on at the

beginning of chloroform inhalation depends on excitation of the vagus nerves, for it does not occur if they have been previously divided. (*Zeitschr. f. Biol.*, xxvii.; *Neue Folge*, x. 3, 365.)

Heymans set himself the task of trying the bactericidal power of bodies which evaporate at a low temperature, hoping in this way to find an ideal antiseptic. The author's experiments were carried on with pure chloroform and ether, the fumes of which, as is already known, produce an arresting on the development of cultures of pyogenic micro-organisms growing in gelatine; the experiments have hitherto only extended so far as to investigate the toxic influence which the applied fumes of chloroform and ether exercised on the skin of rabbits. Heymans used a glass cylinder which was provided with a piece of wadding saturated with chloroform, and applied to the skin (especially to that of the ear) of rabbits, and hermetically fastened in a suitable manner with pig's bladder and thread. All animals to which chloroform had been applied in the manner above-mentioned, generally died between the third and fifth day after the application, and without ever having been narcotised. The chief symptoms were refusal of food, albuminuria, and just before death frequently hæmaturia. After autopsy inflammation and fatty degeneration in the liver were the chief changes found. The effect on the health of the animal if ether was applied was, in comparison to that caused by chloroform, observed to be very small, even if the doses were ten times larger. (*Extrait des Annales de la Société de Méd. de Gand*, 1892.)

A. A. Kanthack has recently published the results of experiments made to investigate the nature of cobra poison, the active principle of which is known to be an albumose. The poison was obtained from the snake by applying pressure to the head, and by this means was squeezed out of the glands. The first drop was not used for research work on account of the poison which stagnates in the ducts. The author found that if the first flow be carefully avoided the reaction is neutral or faintly alkaline. It speedily dries and "leaves a yellow substance, easily pulverisable, resembling gum arabic or dried egg-albumen behind." It gives a beautiful biuret reaction, and with nitric acid a precipitate almost wholly soluble on heating and reprecipitated on cooling, proving the presence of other proteids than albumoses. *Prolonged* boiling destroys the activity of the poison. It was found that concentrated solutions withstood boiling for one or two hours before they lost their poisonous action entirely, though 40—60 minutes sufficed to lessen it considerably. A weak solution, however, could be destroyed in half an hour or twenty minutes. These

results were also obtained with a solution of the pure albumose. If this were free from any other proteid, no precipitate fell, though the solution occasionally became rather opalescent. If, however, a solution of cobra poison were heated, it first became cloudy and then a white precipitate fell. This, no doubt, is due to the albumen contained in the poison as it issues from the glands. A remarkable point was that though the poison lost its toxic properties after being boiled for two or four hours, its solution continued to give the biuret reaction at the close of that time. Diffused light had no effect on a solution of the albumose or the natural poison, as both were kept for eight weeks before a light window before losing their deadly power. The effect of bright sunlight could not be proved on account of the season of the year. Chlorine water, if allowed to act sufficiently long on cobra poison, destroyed its poisonous action entirely. Carbolic acid delayed the action of the poison considerably, and if the latter were not too concentrated, destroyed it altogether. Ammonia considerably diminished the toxic power of cobra poison and if the solution were strong, it completely destroyed the poison.

The author also made experiments in order to try to establish a protection or cure against cobra poison. Sewall had shown that "it was possible by injection of a few minute doses to give pigeons such tolerance of rattlesnake venom that three months after the treatment they were able to withstand what would otherwise be seven times the lethal dose." Animals may be made to withstand large doses of cobra poison, though long intervals must elapse between successive doses, as the accumulative effect of the cobra albumose is well marked. But it was found impossible to establish immunity against the bite of a cobra in this manner, as three animals treated by the same method succumbed when tested with a strong solution of poison. The effect of strychnia was also tried, but whatever dose was given, no benefit resulted, as the animals always died. Nothing, therefore, must be expected to result from this treatment, and no false hopes should be raised as to a cure for the bite of a cobra by strychnia.

The influence of alcohol was also tested, and the active agent of cobra poison was found to be precipitated by, and totally insoluble in, absolute alcohol; but mixtures of alcohol and water are capable of dissolving a certain amount of the poison in proportion to the quantity of water present.

In Part II. of the author's paper he details some investigations made to discover whether cobra poison contains a globulin or not, and he found that the body, called by another observer a globulin, is nothing but a mixture of hetro-albumose and dysalbumose. It

seems from these observations that there is no conclusive evidence of the presence of globulin in cobra poison. In fact, the above tests show that this body does not exist in the venom. A globulin-like body may appear in a solution of cobra albumose after certain manipulations. It seems that prolonged heat decomposes the proto-albumose into hetero and dysalbumoses, and that these bodies are apparently harmless. In opposition to Kühne, the experiments seem to show that the proto-albumose of this venom on dialysis not infrequently throws down a body which is indistinguishable from hetero-albumose. (*Journ. of Physiol.*, xiii. 272.)

C. S. Roy and **J. G. Adami** publish the results of a long series of observations made on the physiology and pathology of the mammalian heart. They have studied the action of the heart in conditions (unexcised and intact) as nearly approaching the normal as they were enabled to make compatible with the employment of exact methods of research. They state the difficulties attendant upon this study, and the means by which these difficulties can be surmounted. Section 3 commences by a consideration of the relationship between the circumference of a hollow spherical muscle and the resistance to contraction of its walls. Reference, too, is made to the elastic resistance which the heart wall itself offers to contraction, and the bearing of this upon the production of negative pressure within its cavity under certain conditions. The effect on the ventricular contraction of changes in the blood-pressure within the aorta and pulmonary arteries is considered, showing how much the blood has in common with the voluntary muscles of the body, and explaining why the amount of residual blood is liable to changes, and the section concludes with a few remarks on "failure of the heart." Section 4 is a study of the effects of the vagus nerve on the heart. The changes in the contraction-volume are shown, and it is pointed out that though at first sight the graphic records seem to show that, other things being equal, the volume of blood expelled at each systole varies in inverse ratio to the rapidity of heart-beat, yet this general law does not hold good for vagus slowing, which is found to be accompanied by a lowering of the output. With moderate slowing, this diminution of the output may be as much as 30 or 35 per cent., and still more with extreme slowing. An increase in the amount of residual blood in the heart is produced by vagus stimulation, proving that this does not necessarily indicate any weakening of the ventricular contractions. Analysis of the myocardiographic records of the action of the vagus on the heart shows that the auricular contractions are weakened or arrested, and that the

effect of the vagus on the force of the auricular contractions bears no constant proportion to the vagus slowing. Strong excitation of the vagus completely arrests the auricles, perhaps for hours. This complete arrest may, in some cases, be preceded by progressive weakening, but occasionally arrest occurs directly after fairly strong beats, or with fairly strong beats occurring at times during the arrest. These latter cases may be explained by weakening of the excitations which reach the auricles from the sinus, though they may possibly be due to diminished excitability of the auricles. The authors find that the distension of the heart during vagus action is due to the ventricles being more expanded both in diastole and in systole. The increased volume of the heart at the end of systole is in spite of the increased contraction volumes. This opposes the conclusions of those who ascribe it to weakening of the ventricular walls. The authors point out that the greatly increased contraction volume increases to a corresponding extent the work done at each contraction. Detailed reasons are given for concluding that this suffices to explain the apparent weakening of the ventricular contractions. The influence of the vagus upon the tonus of the relaxed ventricles is next examined, and it is found that the great distension during vagus action is entirely due to increased intra-ventricular pressure during diastole, and not, as has been thought by some observers, to any change in the elasticity of the relaxed ventricular wall. The cause of the rise of venous (systemic and pulmonary) pressure is found to be due, not to any increase in the amount of blood entering the veins in a given time, or to contractions of the walls of the veins, but to the diminished inflow into the ventricles. The cause of this diminished inflow into the ventricles is twofold, *i.e.*, weakening, or arrest of the auricles and the elastic resistance of the ventricular wall to distension. This explanation applies to both sides of the heart, and observed facts correspond with it. The after-effects of vagus excitation are considered, and the authors show that the temporary increase in the output which is occasionally present may be explained by a temporary increase in the force of the auricular contractions, and by the venous pressure taking some little time to fall after the vagus excitation has ceased. In examining the influence of the vagus on the heart rhythm, it is seen that when the vagus excitation reaches a certain degree (which varies in different animals) the ventricles begin to beat independently of the sinus and auricles, the rhythm, which at the commencement is slow and irregular, becoming gradually fairly rapid and almost completely regular. This independent ventricular rhythm of vagus action is characterised

by the slowness with which it establishes itself. With a certain degree of vagus excitation irregularity of the ventricles necessarily results, in consequence of the sinus and the ideo-ventricular rhythms interfering with one another. This is the common cause of irregularity, and it may also be caused by the auricles not responding to all the impulses which reach them from the sinus. In Section 5, the effect of direct excitation of the augmentor nerves on the heart is studied. These nerves increase the diastolic expansion of the auricles and also increase their systolic contraction, but these two effects do not go together. Excitation of the augmentors increase the output of the heart, owing to the increased force and frequence of the auricular contractions, the result of this being that the pressures in the systemic and pulmonary arteries rise, while the systemic and pulmonary venous pressures fall. The augmentors, on direct stimulation, cause a slight increase in the diastolic expansion of the ventricles, which is passive in nature and due to the increased force of the auricular contraction. The force of the ventricular contractions is increased; they contract more completely, diminishing the quantity of residual blood, in spite of the fact that the arterial pressure is generally somewhat raised. On peripheral excitation of the cut nerves, there is marked weakening of the contractions, both of the auricles and ventricles, this being occasionally followed by a well-marked increase in the force and frequency of the auricular and ventricular contractions. Reflex excitation of the vagus produces results the same as those which occur on direct stimulation of the nerve. Excitation of a mixed nerve, such as the sciatic, generally produces effects on the heart similar in kind to those due to direct stimulation of the augmentors, but the phenomena are complicated by the greater rise of the pressure in the systemic arteries. Occasionally the increase in the force of the ventricle more than counterbalances this increased resistance to contraction, and the amount of residual blood in the left ventricle is reduced; in other cases the increase in force of the ventricular contractions is not sufficient to counterbalance the increased resistance, and the residual blood in the left ventricle is increased. Section 9 shows that excitation of the central end of a mixed nerve, like the sciatic or splanchnic, usually affects both the augmentor and vagus centres in the medulla, and in nearly all cases the augmentor centre is the more strongly excited of the two, so that augmentor effects show themselves during the excitation, but are followed by vagus action on ceasing to excite the nerve. In Section 10, upon the part played by the vagus in the economy, the authors show that vagus excitation relieves the heart of work, and therefore of

waste to as great an extent as is compatible with a continuation of the circulation, and they conclude that the vagus acts as a protective nerve to the heart, reducing the work thrown upon that organ when, from fatigue or other cause, such relief is required by it. The vagus acts principally in the interests of the heart and central nervous system. The power of the vagus over the heart is limited, and the ideo-ventricular mechanism, which comes into play when the vagus action exceeds a certain limit, must be looked upon as a means by which arrest of the circulation and death are prevented, whenever from any cause the nerve exerts a maximum influence. The power of the vagus to lower the excitability of the ventricles makes their temporary arrest impossible; but this reduction of excitability of the ventricles cannot be kept up, no matter how strong the stimuli applied to the nerve for a period long enough to endanger the circulation. Section 11 shows that the function of the augmentors in the economy is to increase the work and tissue waste of the heart as part of the mechanism by which the nervous system governs the circulation, and that the augmentor mechanism sacrifices the heart in order to increase the output of the organ and enable the ventricles to pump out their contents against heightened arterial pressure. Such excessive action is stopped by the vagus, which steps in as soon as the call for increased supply of blood has ceased. In Section 12 the mode of interaction of the vagi and augmentors is considered. When the vagi are paralysed by section or atrophin, the augmentors have no control over the cardiac rhythm, and they can, therefore, only act by inhibiting the influence of the vagi on the rhythmic centre of the heart. When neither nerve is acting on the auricles they contract with a certain force which is increased by the augmentors and diminished or inhibited by the vagi.

The force of the heart's contractions is influenced by other factors than the vagi and augmentors, and other nerves. The pressure of blood in the coronary arteries is one of the most important. Should this be lowered, the contractions of both auricles and ventricles diminish in strength, while a rise of pressure in the systemic arteries causes an increase in the force of the heart's contractions, so that the force of these latter is, to a certain extent, regulated automatically by changes in the blood-pressure in the aorta. Change in the volume of the blood in the body greatly affects the contraction volume and output of the heart. Increase in the work of the ventricles, due to increase in the output, has no tendency to automatically increase the force of the ventricular contractions. The authors refer to the bearing of this in cases of plethora. Increase of the watery constituents of the blood increases the

contraction volume and output to the same extent (though only temporarily) as does transfusion of blood, but acts still more unfavourably on the heart, seeing that the work done by the ventricles is increased, while the nutritive value of the blood supplied to the coronaries is diminished. The increased output of the heart in plethora and in hydræmia is due to rise of pressure in the systemic veins, increasing the volume of blood which enters the right ventricle during diastole. These facts bear upon the treatment of chlorosis and heart disease. In Section 14 the limits of the heart to perform the work thrown upon it are considered, and it is shown that, in spite of the beautiful mechanism by which the force of the ventricular contraction is regulated, the heart, like the voluntary muscles of the body, is liable to fatigue when the work thrown upon it greatly exceeds that required to maintain the circulation under ordinary circumstances. Exertion and endurance of fatigue during active muscular exertion are limited mainly by the limited power of the heart to continue supplying the increased amount of blood required by the acting voluntary muscles. Luxuries which are limited or forbidden in "training," and which are known to hinder prolonged exertion, such as water, alcohol, tobacco, caffein, all directly weaken the force of the heart's contractions, and, in the case of water, place the organ under a disadvantage. Fatigue of the heart leads to dilatation of that organ. On comparing the power of fatigued ventricles to carry on increased work, as compared with unfatigued ventricles, it is found that not only is the strengthening effect of the augmentor nerves upon the individual contractions less in the former case, but also that the fatigued, and therefore dilated, heart is unfavourably placed for meeting increase in the work thrown upon it. The irregularities of the heart in disease may be explained by the mode in which the vagus nerve, when acting powerfully, releases the ventricles from the control of the rhythmic centre in the sinus. The irregular heart expends more energy, and its tissues are therefore more wasted for a given amount of work than the heart which is beating regularly. The effect on the heart of imperfect aëration of the blood is, first of all, to produce powerful vagus action from the medullary centre. Besides the vagus action it can be shown that temporary asphyxia causes progressive weakening both of the auricles and of the ventricles, and the considerable rise of pressure in the systemic arteries in asphyxia is accompanied by vagus effects upon the heart, and not by augmentor action, as is the case, so far as is known, in all instances in which the vaso-constrictor centre is excited in the normal individual. The changes that take place in the heart and

circulation during asphyxia lead to the conclusion that when the total amount of oxygen in the blood is lowered, it is for the benefit of the economy that those organs, such as the central nervous system, whose continuous blood supply is a vital necessity, should be richly supplied with blood by constriction of the vessels of the spleen, kidney, and digestive system, whose blood supply can be cut off temporarily without danger to life, and also that the heart should carry on the circulation in a manner involving as little waste as possible of its own substance. This result, as is seen, it is the function of the vagus nerve to accomplish. (*Phil. Trans.*, clxxxiii. 199.)

W. Townsend Porter records researches on the filling of the heart, which, he says, is the result of differences of pressure between the great veins, auricle and ventricle. He has sought to determine these differences and their relative importance, and the results secured have been confirmed, as far as possible, by simultaneous measurements of the pressure in auricle and ventricle with mercurial manometers. In the author's experiments on the filling of the auricle, he finds that the flow from the veins into the auricle is intermittent, ceasing during the systolic and the first diastolic rise. The second diastolic fall is caused by the contraction of the ventricle, and not by the relaxation of the auricle. The second diastolic fall is an important factor in the filling of the auricle, and its importance grows with an increase in the frequency of the heart. The negative pressure in the ventricle has little effect upon the pressure in the auricle.

As to the filling of the ventricle it is found that negative pressure in the left ventricle is sometimes absent, often slight, and sometimes great. The minimum mercurial manometer was used in fifteen experiments with open chest; in five no negative pressure could be demonstrated; with the chest closed, negative pressure was found in the left ventricle in five cases out of six. Negative pressure with open chest was sought for and found in the right ventricle twice; in these animals a negative pressure was found also in the left ventricle. Negative pressure in the auricle with open chest is often absent, when present is relatively trifling. The positive pressure in the auricle is low. A simultaneous record of the pressure in the left ventricle and left auricle shows that a high degree of negative pressure may be present in the ventricle, while at the same time no negative pressure is present in the auricle. The author assumes that a negative pressure in the ventricle quickly disappears, provided its direct cause or causes do not continue to act. The conclusions to be drawn concerning the filling of the ventricle may be

summarised as follows:—Blood flowed into the ventricle from the opening of the auriculo-ventricular valves to that moment in ventricular systole when the pressure in the ventricle rose above that in the auricle. In these experiments the auriculo-ventricular valves closed during the first moments of ventricular systole. The ventricular negative pressure occurs after ventricular systole. There are reasons for distinguishing two forms—one occurring before the auriculo-ventricular stream begins to flow; the other at the same time as, or a little later than, the beginning of the flow. The negative pressure in the ventricle, with open chest, fails to greatly influence the pressure in the auricle. The duration of negative pressure may be greater in a very frequent than in a comparatively infrequent heart. There are facts which seem to indicate that the ventricle in diastole may undergo changes in volume whose cause lies in the ventricular muscle itself. (*Jour. of Physiol.*, xiii. 513.)

H. P. Dean, in a paper on cerebro-spinal pressure, remarks that in considering the subject of compression of the brain it must be understood that there are two distinct varieties of compression. These generally occur together, but occasionally one may be present without the other. They are:—(1) A general compression of the whole central nervous system brought about by a rise in the pressure of the cerebro-spinal fluid in the sub-arachnoidal space; (2) a local compression of some particular portion of the central nervous system, the compressing agent exerting its action on the nervous tissue directly. The changes in the brain and spinal cord are brought about by continual variations in the blood pressure, and are able to take place within the firm walls of the cranium and vertebral column. The author suggests that the cerebro-spinal cavity may be regarded as an oncometer which works accurately when the changes of pressure are not considerable, but that when the pressure has been allowed to rise beyond a certain height, which differs in different animals, there is a slight amount of leakage. By injected normal saline solution this leakage can be compensated. When the sub-arachnoidal pressure rises as a result of an increase in the volume of the brain and spinal cord, only a small portion of that increase, varying from one-third to one-tenth, is due to increase in volume of the spinal cord. Constant variations occur in the volume of the brain and spinal cord. In his experiments on the effects of alterations in the size of the cerebro-spinal cavity upon the cerebro-spinal pressure, the author finds that when the cranial cavity is reduced in size, the cerebro-spinal pressure begins to rise at once, and that as the diminution in size gradually progresses, there is a similar

gradual increase in the cerebro-spinal pressure. The theory that the theca vertebralis has considerable distensibility is probably incorrect. It may have arisen from the fact that the cavity can be considerably diminished in size without any symptoms appearing. The fact that there are no symptoms when the cranial cavity is diminished in volume to a slight extent only, is not to be explained by a compensatory outflow of cerebro-spinal fluid along the perineural lymph tracks and into the distended theca vertebralis, but by the fact that the sub-arachnoidal pressure has to reach a certain magnitude before it can interfere with the circulation of the brain sufficiently to derange the functions of this organ. In observations made on the effect of stimulation of sensory nerves, an effect was produced on the general blood pressure, the cerebro-spinal pressure increased, and after the stimulation was removed the cerebro-spinal pressure fell along with the blood pressure. After stimulation of the peripheral end of the vagus, although there is always a fall in the arterial pressure, yet in the cerebro-spinal pressure one of two results occurs—first, a decided fall in the cerebro-spinal pressure, which is the most usual; secondly, either a very slight rise or no alteration. By compressing the thoracic aorta a considerable rise is always produced in the arterial pressure. A rise is also produced in the cerebro-spinal pressure, but this is not so abrupt as that of the arterial pressure. By allowing blood to be lost, both the arterial and the cerebro-spinal pressures fall, and when the amount of blood lost is great the fall of pressure is very marked. When chloroform is given there is a distinct fall of the cerebro-spinal pressure, and it occurs before any appreciable effect on the arterial pressure is produced. Soon, however, with the fall of the latter, there is a marked rise of cerebro-spinal pressure. During the first stage of asphyxia a marked contraction of the brain was noticed to accompany the rise in arterial pressure. The author relates some of the disturbances of the circulation in the brain, especially the spreading œdema, caused by the introduction of a foreign body into the cranial cavity, and the serious consequences that may follow the removal of the compressing agent. Considerable support is given to the results of these experiments by cases of meningeal hæmorrhage occurring in surgical practice, and some suggestions are made by the author for the treatment of these cases. Certain alterations in the structure of the compressed area are described. The author also made observations on the surface temperature of the two sides of the body following local compression by experiments on nine animals, in which local cerebral compression had been produced

by the insertion of glass discs, and found that with a small disc the surface temperature of the axilla opposite to the hemisphere compressed is always higher than that of the axilla of the same side as the compressed hemisphere. That is, if a small disc be inserted over the left hemisphere, the surface temperature of the right side of the body is always higher than that of the left side of the body. With a large disc the result is exactly reversed. It is thought that a small disc produces an irritative lesion of the inhibitory mechanism of the vaso-motor centre supplying the opposite side of the body, and so a dilatation of the cutaneous is produced causing a rise in the surface temperature. With a small, an irritative lesion is produced causing an elevation of the surface temperature of the opposite side of the body, and a contraction of the pupil of the eye of the same side. With a large disc, a paralytic lesion is produced, causing a depression of the temperature of the opposite side, and dilatation of the pupil of the same side. (*Jour. of Pathology*, i. 26.)

A. **Heffter** has sought to find on what food the heart of the frog gives most work, and what components of the blood are necessary for this. He estimates the absolute force, the size, and also the frequency of the pulse. It is proved that the nourishment given by the blood of bullocks, horses, or pigs, is extremely good for work of the frog's heart. The serum of blood, on the contrary, cannot support the beating heart so well as blood itself. "Lakey" blood, or free oxy-hæmoglobin, is also found to be incapable of supporting the heart; that property appears to belong to the blood corpuscles. Nevertheless it is found that blood corpuscles separated by the centrifuge and suspended in normal saline cannot of themselves support the activity of the heart. If, however, they are suspended in a solution of egg-albumen, or in 2 per cent. neutral solution of gum arabic, the heart works in a perfectly normal manner. Therefore the red corpuscles must be considered the most important factor for supporting the heart's activity, but they must, for that purpose, be suspended in a liquid the physical properties of which are similar to those of blood serum. (*Arch. f. Exp. Pathologie und Pharmacologie*, xxix., s. 41.)

A summary only of the principal points of interest in the long and careful paper by **G. N. Stewart** can be given. The subject is the influence of temperature and of endocardiac pressure on the heart, and particularly on the action of the vagus and cardiac sympathetic nerves. Of all the physical conditions which affect physiological activity, there is none which is so profound as temperature. The heart of cold-blooded animals,

such as toad and frog, is normally subject to wide fluctuations of temperature, so that for a very great range the conditions are still physiological. Although it is not possible to confine the action to any particular constituent of the heart, yet it is certain that the cardiac muscle is affected. The author has made a series of observations on the influence of the vagus and sympathetic nerves at temperatures ranging between the extreme limits compatible with the life of the tissues. (When the word "vagus" is used without qualification in this paper it signifies the mixed vago-sympathetic nerve.) The results of his experiments on the effect of temperature on the action of the vagus fell into two divisions:—(1) The effect of temperature on the inhibitory action. The action of the vagus is very much influenced by the temperature of the heart, but in general only quantitatively, and not qualitatively. For example, if stimulation of the vagus at a medium temperature causes, as its primary effect, inhibition in a broad sense, then whether the temperature be raised or lowered, the primary action of the nerve, when its action persists at all, is inhibitory. If, on the other hand, as sometimes occurs, the primary action of the fresh nerve is augmentor at a medium temperature, it is also augmentor at any other temperature at which there is any action at all. The influence of temperature, which can affect the beat of the heart more than atropia, cannot, like atropia, affect the fundamental type of action of the vagus nerve. In the cooled heart it is the inhibitory action rather than the augmentor which persists. A primary inhibitory action is sometimes replaced in the course of an experiment, during which the heart has been cooled or heated, by a primary augmentor action. This is a common occurrence in hot weather. (2) As the temperature of the heart is lowered from a medium temperature, the inhibitory activity of the vagus is diminished, by whatever criterion that activity is estimated. If at a medium temperature, stimulation of the vagus causes complete quiescence of the whole heart, then, as the temperature is decreased, it is possible to obtain, with the same strength of stimulus, only a diminution in the force of the auricular beats, sometimes accompanied by diminution in the force of the ventricular beats. As the temperature is lowered still further, the effect upon the force of the ventricular beats first disappears, then the effect upon the auricle. Ultimately, at a very low temperature (0°—2° C.), no effect is caused by the strongest stimulation of the vagus. If the primary effect of vagus stimulation at the starting temperature be slowing of the beat without diminution in the amplitude, this is also the effect at lower temperature. If the ventricle alone is cooled,

complete quiescence of the heart may be obtained by stimulation of the vagus at very low temperature. Stimulation of the sinus is generally effective in causing inhibition at a lower temperature than stimulation of the vagus trunk. Stimulation of the auricle causes similar effects, though less marked, and more strictly confined to the auricular nerve. As the temperature is increased from a medium temperature the inhibitory action of the vagus is increased, whatever effect is taken as to the test of its activity.

The influence of the temperature of the heart on the activity of the cardiac sympathetic nerve.—When the temperature of the heart is diminished below the medium temperature, the activity of the sympathetic is lessened as regards the alteration both in rate and in the amplitude of the beat. Of the two alterations which stimulation of the sympathetic may cause in the beat, increase of rate and of amplitude, the former is that which is relatively most prominent at low temperatures. When the activity of the sympathetic is estimated by the alteration which stimulation of it produces in the frequency of the beat, and a curve is drawn of which the ordinates are proportional to this ratio and the abscissæ to the temperature, this curve in general sinks towards the abscissa axis as the temperature is decreased below the ordinary till it reaches the minimum, at which it may remain when the temperature is still further diminished, or it may even begin to rise again. When the vagus on one side and the sympathetic on the other are stimulated alternately as the heart is progressively cooled, the sympathetic generally becomes ineffective at a temperature for which the vagus is still active. As the temperature is increased from the medium, the activity of the sympathetic increases. In general it may be said that a temperature which is favourable to the action of the vagus nerve is unfavourable to the action of the sympathetic, and *vice versâ.* When the normal changes in the heart are rendered sluggish by cold, it is not only less easy to quicken its beat, but it is less easy to stop it. When these changes are quickened and the molecular mobility of the heart is increased by heat, it is easy for it to slide either into inhibition or into augmentation. The temperature of the heat standstill of the heart varies inversely with the rhythmical power of the muscle. When the heart is distended with liquid at a high pressure (20—40 c.m. of normal saline) and is then heated, an imperfect "tetanus" results, in which a series of rapid small contractions is superposed on a more lasting contraction, which might be described either as tonic or tetanic, and which precedes the relaxation into diastolic standstill. When the temperature is lowered, the heart again begins to beat, unless it

has been heated more than is sufficient to produce this standstill. At low temperatures the tone of the heart, and particularly of the ventricle, is decidedly increased. Although the contractions are so slow, the relaxation is less than at the ordinary or at higher temperatures. The beats at low temperature are large and vigorous, although slow. It has sometimes been stated that the size of the beat is diminished at low temperature, and this is so for a temperature bordering on that at which the heart stops in a cold standstill. But the contractions are often quite as large at a temperature a degree or two above zero, as at the ordinary temperature. The activity of the sympathetic in the frog is not abolished or apparently reduced by an increase of cardiac pressure far above that which suffices first to weaken and then to destroy the inhibitory action of the vagus. The increase in rate and strength of the beat which has sometimes been observed as a result of stimulation of the mixed vagus trunk, is due to the sympathetic fibres in it. Under certain conditions, such as a moderately high endocardiac pressure, the systole may apparently be lengthened at the same time that the rate of the heart is accelerated by stimulation of the sympathetic. (*Journ. of Physiol.*, xiii. 59.)

At the Congress of Physiologists held at Liége **Hürthle** demonstrated a method for mechanically registering the time of occurrence of the cardiac sounds. A little microphone is applied to the chest, but not where the actual movement of the cardiac impulse can reach it. The cardiac sounds upon the microphone and through it cause variation of the current in the primary of an induction apparatus. If a telephone is inserted in the secondary circuit one can hear sounds corresponding with the heart sounds; if a fresh nerve-muscle preparation (from the frog) be inserted into the secondary circuit, the muscle contracts at each cardiac sound. It is possible thus to register mechanically the time of occurrence of the cardiac sound. If at the same time a cardiograph applied to the region of the cardiac impulse on the chest wall is set to write on the cylinder under the myograph, it is easy to see at what period of the cardiographic tracing the first and second sounds of the heart appear. The first cardiac sound occurs at the beginning of, or somewhere within the ascent of, the cardiagraph tracing; the second sound occurs always in the first half of the descending limb of the tracing. (*Notice sur le 2me Congrès Intern. de Physiol.*, p. 1., Fredericq.)

Digestion and nutrition.

Holl controverts the widely accepted view of Martius and Gegenbauer that the humerus is a bone that is twisted on its

long axis, and that the torsion of the humerus can smooth away the difficulty of homologising the fore limb and the hind limb. The spiral course of the outer angle of the humerus is no evidence of a torsion of the bone; it is the product of grooving by the musculature. Neither cross sections nor the grain of the decalcified bone supports the idea of the bone having undergone torsion. In accordance with Kölliker, Holl finds that no trace of any torsion of the limb is to be seen in the early stages of its development. He finds that the course of the nerve-trunks in the limb is such that no torsion is indicated in the nerve-bundles. The alterations in position which the limbs undergo in their development are (1) a turning of the young and fin-like limb in such a way that the ventral side of it approaches the anterior side of the body; (2) a shifting tailwards of the more developed and jointed limb; (3) rotation of the fore-limb so that the extensor surface comes to face tailwards; a rotation of the hind limb so that the extensor aspect of it comes to face headwards. The two limbs, fore and hind, do not rotate equally; the upper limb rotates the more. The rotation goes on at hip-joint and shoulder-joint, according to Hatschek; according to Holl certainly at the hip, but not at the shoulder-joint. The rotation of the upper limb is due to shifting of the whole shoulder girdle on the trunk, and is complicated by adduction of the limb to the trunk. (*Sitzungs. ber. d. k. Akad. d. Wissensch. Wien.*, Feb.)

J. Rose Bradford publishes a preliminary report of an important series of experiments to elucidate the influence of the kidney on metabolism. Fifteen experiments were performed in the following way: A dog is fed for a week upon a weighed diet containing a known quantity of nitrogen, and the amount of urine passed daily measured, and the quantity of urea and the total nitrogen in it determined. The weight of the fæces and the amount of nitrogen in them are also determined. A large wedge of renal tissue is then removed from one kidney. The shock of the operation passes off in about twenty-four hours; but for two or three days there is some hæmaturia, and the appetite is poor. All signs of illness pass completely in the course of a week. The animal is again fed on a known diet, and the ingesta and excreta are determined—for a period of from one to six weeks. At first the urine is frequently abundant, and the specific gravity of it is low; but this soon passes off, and the urine returns to its normal quantity and density. After the interval of recovery the kidney which had not been touched at the first operation is removed *in toto*. The results of the removal of the second kidney are at first very slight—there is little shock or

hæmorrhage as compared with the first operation. The remote effects, however, are very marked—extreme wasting, hydruria, and polyuria occur, and with these a fall in the body-temperature and a great increase in the nitrogenous extractions of the tissues. The increase in the water of the urine is greater than the increase in the urea. This polyuria is accompanied by great wasting, which is not materially checked by a liberal diet. There is great thirst, and the temperature falls about 5° Fahr. Death follows in from two to six weeks. The increased flow of urine is not dependent simply upon increased secretion of urea, since the former may exist without the latter, although the latter not without the former. The fatal course of the experiment is intimately dependent on the amount of kidney removed. When a dog is left with only one-fourth of its total kidney substance, a condition of extreme hydruria invariably results. This hydruria is accompanied by a large increase in the output of urea. If the ingesta are diminished to zero, the output of urea remains at the height it reached with a diet sufficient to maintain the weight of the animal when in a normal condition.

By removal of a smaller amount of kidney, hydruria alone is produced. When hydruria and polyuria are both produced by removal of three-fourths of the total kidney weight, the hydruria precedes the polyuria. In the disease produced there are indeed two stages. In the first stage the normal output of urea is maintained, but the method of its excretion is altered, so that the quantity of urinary water is greatly increased; in the second stage the quantity of urine is still further increased, with an increase in the urea, accompanied by emaciation, etc.

Character of the urine.—The urine passed after the second operation contrasts greatly with the normal urine of the dog, inasmuch as it is very pale, abundant, and of low specific gravity (1·007—1·020). The urine contains neither albumen nor sugar. The blood pressure is high, considering the weak condition of the animal.

Although the animals are greatly emaciated, some fatty tissue remains, especially in the omentum. There is an increase in the amount of cerebro-spinal fluid. The fragment of kidney left in the body has never been found hypertrophied; often it has been found distinctly atrophied.

Nitrogenous extractives of the blood and tissues.—When hydruria has given way to polyuria the amount of urea in the blood and tissues—an amount which had until then been only slightly above the normal—begins to increase enormously. There may

be in the blood twenty times the normal amount of "urea" at this time, although the animal is still excreting an amount greatly above the normal output. The excess of urea in the muscles is greater than in the liver and brain. This does not prove that it is produced in the muscles, for a similar excess in the muscles occurs when solution of urea is simply injected into the jugular vein, and also after ligature of both ureters.

The disturbance of nutrition with increased production of urea described above does not follow destruction of the renal plexus, nor does it follow free incision of the kidney with subsequent suturing of the damaged organ. It is a phenomenon closely connected with the removal of large quantities of kidney—*i.e.*, half of one kidney and the whole of the second. Inasmuch as the phenomena do not ensue after the first and more severe operation, but only after the second and comparatively trivial operation, it must be concluded that they are related to the quantity of kidney removed, and not to the shock of the operation. (*Proc. Roy. Soc.*, li. 25.)

Minkowski communicates the results of further investigations on diabetes mellitus after extirpation of the pancreas. In experiments on cats and pigs he found that if nearly the whole of the pancreas were extirpated, diabetes could be produced; this result was not obtained if the experiment was tried on birds and frogs. With dogs the experiment was so performed that pieces of the pancreas were transplanted on the outside of the abdominal cavity; the author then removed what was left behind in the abdominal cavity, and no diabetes appeared, but a worse form of it made its appearance if he afterwards removed the ingrafted pieces. The excretion of sugar reaches its maximum on the third day after the extirpation. After that epoch, whether during fast or upon an entirely meat diet, the nitrogen contained in the urine bears a certain and constant ratio to the sugar in the urine, viz., as 1 to 2·8. Possibly this ratio expresses the proportion in which sugar is made from proteid material in the body. The salivary glands cannot take the place of the pancreas as regards the formation in, and excretion from, the body of sugar. The glycosuria which results from extirpation of the pancreas differs from that which is produced by Phloridzin in the fact that the latter is obtainable in all animals, and is accompanied by a low percentage of sugar in the blood, while the former cannot be produced in birds or in frogs, and is accompanied by an increase in the sugar of the blood. A dose of phloridzin increases the amount of sugar excreted in pancreatic diabetes. If the kidneys be extirpated in a dog with pancreatic diabetes, there

follows a marked increase of the percentage of sugar in the blood. The glycogen normally present in the liver early disappears in pancreatic diabetes. Lævorotatory sugars can be assimilated by animal after removal of the pancreas just as they can by certain diabetic patients, without the production of any increase in the urinary sugar. (*Berlin Klin. Wochenschr.*, No. 5, 1892.)

Most of the facts ascertained by Minkowski have been also observed by Hédon. **Hédon** lays some stress on the variability of the effects in different individuals. Usually, severe and fatal diabetes follows complete extirpation of the pancreas, but not incomplete extirpation; but occasionally incomplete removal of the gland induces fatal diabetes, and on the other hand complete extirpation fails sometimes to cause severe or lasting diabetes at all. This cannot be explained by vicarious action of the salivary glands, nor by occlusion of the bile duct, because removal of the salivary gland, or of the head of the pancreas, including the bile duct, has no effect upon the result. In pancreatic diabetes the tissues do not appear to use up the sugar in the blood so quickly as under normal circumstances, for if the aorta and vena cava are ligated just below the diaphragm in a normal animal the sugar rapidly disappears from the circulation, whereas after removal of the pancreas it does not become diminished. at any rate not in the course of an hour. (*Arch. de Physiol.* [5], iv. 245.)

The theory invoked by Lépine to account for pancreatic diabetes, namely, the presence in normal blood of a ferment which breaks down the grape-sugar, has been again disputed by Arthus (*Arch. de Physiol.*, vi. 268), who finds that in fresh blood there is no glycolytic power, but that in blood kept at 0° C. for 48 hrs. there is considerable glycolytic power. The glycolysis is according to him due to a ferment which is developed in the blood as it dies. Lépine and Barral have, however, tested their previous result as follows :--Both jugular veins were prepared, and the percentage of sugar in one determined at once, the percentage in the other being examined two hours later, the excised vein being inverted every five minutes to prevent the corpuscles forming a sediment. They declare that the sugar falls from ·074 per cent. to ·047 per cent. in the interval. The examination of the question of glycolysis is leading to a most needful revision of our methods for estimating sugar in the blood. The proteids of the blood have to be precipitated before the sugar present in it can be quantitatively estimated. Most precipitants of proteids carry down with them some of the sugar, as pointed out by Schenck in 1890. A good new method has been introduced

by Abeles (*Zeits. f. Physiol. Chemie*, xv. 72). The measured quantity of blood is mixed with an equal bulk of absolute alcohol in which zinc acetate to the extent of 5 per cent. of the weight of the blood is dissolved. Another method is that of Seegen, which is modified from the older plan of Schmidt-Mulheim. To the diluted blood is added ferric chloride and sodium acetate, and then a sufficiency of sodium bicarbonate; the mixture is boiled and filtered. (*Centralb. f. Physiol.*, vi. 501.)

G. Bunge has made a comparison between our more important foods and milk, which shows that the former contain a much greater quantity of iron than the latter. The fact is striking, for this particular reason—*i.e.*, that the other constituents of the ash are contained in the milk in exactly the same proportion as in the organism of the suckling child itself, an arrangement which is not only beneficial to the child, but also to the mother. This relative want of iron in milk for the suckling's nourishment is compensated for by the relatively high amount of iron which is contained in the organism of the newly-born mammal. The author's analysis shows that with newly-born rabbits, the content of iron in the organism decreases so long as they are nourished by milk, but when they begin to feed themselves on vegetables rich in iron, the quantity of iron in their bodies again increases. It happens otherwise with guinea-pigs. With them nourishment by milk plays a very trifling part—they begin to eat vegetables the day they are born, and the quantity of iron contained in them at birth is very small. (*Zeitschr. f. Physiol. Chem.*, xvi. 173.)

C. Jacoby and **W. V. Sobieranski**, by means of sodium sulphindigotate solution, which colours only the epithelium of tubuli contorti and Henle's "loop," and by carmine sodium solution, which colours only the capillaries of the glomeruli, combined with use of Jacoby's hæmatisator (an instrument for keeping up artificial respiration in an excised organ), have investigated the living kidney, and found that the microscopical appearance, at least qualitatively, resembles that of the kidney in its normal state. They further investigated the secretion which the use of the above-mentioned hæmatisator furnishes. According to their analysis it contained about ·5 per cent. of urea, so that it can be regarded as a normal, if also as a matter of fact diluted, secretion. (*Arch. f. Path. u. Pharm.*, xxix. 25.)

M. Greenwood has made observations on retractile cilia in the intestine of Lumbricus terrestris. Heidenhain recently published a paper on the physiology of the intestinal mucous membrane, and based his conclusions on varied investigations of the intestines

of mammals and amphibia. The authoress carried out her experiments entirely on earthworms. In this animal, posterior to the œsophagus no distinct glandular diverticula are separated off from the alimentary canal, and even if the œsophagus be included, the secretion of the chalk glands can hardly be regarded as more than indirectly concerned in the digestion of food. The formation of the main part of any secretion used in digestion, and the absorption of digested matter, depend on the epithelial lining of the intestine; the structure of this lining the authoress has described in some detail. The intestine is invested externally—that is, on the side turned towards the body cavity—with clustering yellow cells, which are generally regarded as modified cells of the cœlomic epithelium. The dorsal wall of the gut in Lumbricus has a longitudinal ridge of a highly vascular structure; yellow cells like those which form the external coat of the gut almost cover its convexity. It begins gradually, and gradually fades away as a slight median fold, but in a certain region attains such complexity as to make it almost fan-shaped in transverse section. The epithelium consists of two different kinds of cells—firstly of secreting cells which the authoress considers unicellular glands. These are elongated oval cells, hardly reaching the free surface of the gut. In prepared specimens one perceives a fine network in these cells—the nucleus lies bedded in this. The second kind of cells are the ciliated cells. Some of them possess cilia, similar to those in the mucous membrane in the mouth of Triton, projecting from an apparently hyaline rim. Other very long extended cells with distinct longitudinal striation appear as continuations of the cilia which pierce the hyaline rim. Another and third kind of cell possesses strikingly short cilia and a very thick rim, under which lies a large vacuole. Besides the above-named cells others were found which possess Heidenhain's "rodlets."

The conclusions drawn from the above investigations are as follows:—

(1) The digestion of food in Lumbricus is effected chiefly by secretion, which takes its origin in the granules of unicellular glands. The glandular cells are isolated. They occasionally occur throughout the length of the longitudinal ridge, and also over corresponding regions of the gut walls. They abound most in a zone, the limits of which are rather variable, but which might be placed between segments 25 and 50. At any point this longitudinal ridge is more glandular than are the walls of the alimentary canal.

(2) The absorption of digested food is apparently carried out

by the cells by which the glands are surrounded. These are elongated; they branch internally, and have not firm lateral connections. Their external edges (those turned toward the cavity of the intestine) expand, and appear to meet over the depressed gland cells. A hyaline rim or band is present, and may be pierced by, or perhaps gives rise to, cilia; but during the digestion of fat, any epithelium cells by which it is absorbed show a striated or rodded external border, replacing the active cilia. These cells are localised in a zone-like fashion, and recall the distribution of the unicellular glands, and are more striking on the longitudinal ridge than on the gut walls.

It is less easy to distinguish a connection between the absorption of matters in solution, and structural change in the epithelium cells, but it may be mentioned that cilia are occasionally absent from the larger part of the longitudinal ridge—*i.e.*, from an area much larger than that over which the ingestion of fat extends.

(3) It seems possible that there is a certain excretion of solid matter into the cavity of the gut of Lumbricus. This matter is gathered into masses below or between the epithelium cells, and the fact that these accumulations vary in solidity perhaps points to the occurrence of some final metabolic process, while they still ramain between the intestinal cells. (*Journ. of Physiol.*, xiii. 239.)

In researches on ferment actions of the pancreas in different animals by **V. Harris** and **W. Gow** the authors sought to obtain information on the following points, viz.:—

(1) Whether the ferments which the pancreas is generally supposed to possess exist in the pancreases of animals of different classes, and if so, whether there is a great difference to be found in the activity or quantity of each ferment in each class.

(2) Whether the activity or amount of the ferments has any constant relation to the food of the animal.

(3) Whether the ferments of the human pancreas are markedly affected in activity or quantity in morbid conditions of the body.

(4) Whether, besides the generally accepted pancreatic ferments, the gland possesses additional ferment action, such as in inverting cane sugar, or in having any chemical effect upon dry starch. The experiments made to test whether the usual ferments were present in the mammals that the authors were able to employ are in two divisions, qualitative and quantitative experiments; the former dealing with four different ferment actions, the latter with only two. In the qualitative experiments many, more or less complete, are made on the pancreases of various animals to discover whether they contain ferments (1) converting

starch into sugar—*i.e.*, diastasic or amylolytic; (2) converting proteids into peptones—*i.e.*, proteolytic; (3) splitting fats into their fatty acids and glycerine—*i.e.*, lipolytic; (4) curdling milk—*i.e.*, rennet. The experiments detailed are very numerous, with varying amounts of the extracts, and were done in flasks in the cases of the amylolytic, tryptic, and rennet ferments. The observations made on flask digestion of starch appear to show:—(1) That a certain definite amount of ferment must be present before any change occurs, as below a certain minimum no diastasic action can be demonstrated. This fact was observed by the authors several times. (2) That a certain definite quantity of the pancreatic extract can do a certain amount of work and no more. The amount of fermentation done varies in different animals considerably. The action of the ferment is therefore limited, and the removal of the product of the action—*i.e.*, the dextrin and sugar formed is not sufficient to indefinitely prolong the change. (3) that the power of conversion of starch into dextrin may be very active, whilst the further power of changing dextrin into sugar may be only feebly present. (4) That a moderately high temperature, viz., 40° C. to 45° C., seems to be the optimum for the diastasic change. The proteolytic or tryptic experiments were also flask experiments, and the tryptic action of the pancreatic extracts on fibrin are found to be active with man, lion, pig, dog, cat, fox, deer, eagle, ox, etc., slightly active with gazelle, badger, leopard, serval, and wallaby, but in no case is it wholly inactive. The authors are not able to demonstrate the presence of any fat-splitting ferments in extracts of pancreases which have been kept in spirit, but in some instances, however, there is satisfactory evidence of the presence of a ferment in fresh pancreases acting upon fats. This action is most marked in the dog's pancreas, less so in the pig, and is practically absent in the human pancreas, and also in the cat's. Brine extracts of pancreas mixed with oil fail to lead to development of any acid. The authors think there is no possible doubt as to the great frequency of a rennet ferment existing in pancreatic juice. The pancreatic extracts of man, dog, pig, and cat, are all very active in their power of curdling milk. Also those in several varieties of eagle, but that of the rhea is inactive. There seems to be no relation between the activity of the rennet ferment and that of the diastasic ferment. The pancreas of the horse produces rapid and firm clotting, but its diastasic activity is very slight.

According to another observer's recent researches the presence of sodium chloride appears to aid the action of the rennet ferment. Differences seem to exist in the pancreatic extracts of different

animals. The authors have not been able to discover any fixed rate as to the amount or activity of the pancreatic ferments in different classes of mammals. It is remarkable that such irregular results should be obtained. This irregularity may be due to the condition of the animal at the time of death, whether healthy or unhealthy, in good condition or wasted, and also the time which has elapsed since its last meal. Of the four ferments dealt with, the tryptic ferment is by far the most general and hardy; next to that the rennet, next the diastasic, and lastly the fat-splitting ferment. It appears that the pancreases of carnivorous animals have very little or no power of converting starch into sugar, and do not possess any rennet ferment. The fat-splitting ferment is not commonly present in pancreatic extracts. No conclusions can be drawn with reference to the rennet ferment, except that it is more often present than not, and that in some pancreases it is very powerful. It is an interesting fact that only the following animals appear in the first class as regards the activities of all of their ferments—the man, pig, ox, and sea-eagle. The authors think the general statement allowable that the activity of the human pancreas may be considerably diminished in wasting disease. Several experiments were made with pigs' pancreases to discover whether any inversive ferment is present which has the power of converting cane-sugar into dextrose and lævulose. Neither active brine extracts of pancreas nor fresh pig's pancreas has the power of inverting cane-sugar into an alkaline medium. Fresh pig's pancreas appears to have the power of converting raw starch into dextrin. These experiments prove that antiseptics do not interfere with the action of the unorganised ferments of the pancreas. (*Journ. of Physiol.*, xiii. 469.)

S. Fränkel finds that to obtain glycogen without boiling, the following is a very simple method—it instantly furnishes a perfectly pure preparation and serves for quantitative estimation. To obtain large quantities the quickly-mashed liver is thrown into a solution of from 2 to 4 per cent. trichloracetic acid. The organ is rubbed down in this for a short time, then is filtered, afterwards washed with the same solution. The filtrate is precipitated with twice its volume of alcohol, the glycogen put on a filter with 60 per cent. alcohol till the cessation of acid reaction, then washed with 95 per cent. absolute alcohol, finally with ether. The product is snow-white, almost free of ash, quite free of nitrogen. In quantitative estimations the organ is rubbed down after filtering off the first extract with water to which some trichloracetic acid has been added, till the filtrate yields no longer an iodine reaction. The glycogen prepared by

this method has been used—it possesses the usual well-known properties. Its composition corresponds with Küby's formula: $6 (C_6H_{10} O_5) + H_2 O$. The author has recently determined the rotation power of glycogen, because the previous results differ very much. He finds that the substance dried at 110° has a pacific rotation: $[a]_D = 197{\cdot}891°$, either when prepared according to new methods or according to old methods.

If liver quickly ground down is hardened in 95 per cent., then in absolute alcohol (the alcohol afterwards washed out with ether) and put in the air to dry, no trace of glycogen can be found in the finely-ground mass left in the water. With the addition of sublimate or chloride of zinc hydrochloric acid, mercury potassium iodide to the water, boiling with or without caustic potash, glycogen is dissolved at once. Either the glycogen is so enveloped in coagulated albumen by the action of the alcohol that it cannot dissolve, or it may be part of a complicated formation contained in the liver, and which is insoluble in water. If one mixes egg-albumen with glycogen and adds to the solution alcohol, and rubs down the precipitate, after treatment with ether the glycogen cannot be dissolved either by cold water or sublimate or zinc chloride or trichloracetic acid; it can only be extracted by long boiling with or without the addition of alcohol. The author inclines to the view that glycogen is not free in the liver, and he goes on to state the following investigations:—No glycogen, or only a small quantity, can be extracted from a fresh liver which has been ground down with water or normal saline, which has already been observed by Langley and Nasse. The latter employed chloroform water, and was of an opinion that the glycogen could not be found in the fluid because on its entering solution it was at once turned into sugar by the liver ferment.

The author, in order to on the one hand avoid breaking up of the hypothetical compound containing glycogen, and on the other hand to set aside all ferment action, rubbed down fresh liver with 5 per cent. caustic potash solution. The filtrate when precipitated with alcohol does not yield glycogen. This succeeds even better with concentrated solution of soda, which destroys the ferment of the liver. As to what is the nature of the supposed body containing the glycogen the author concludes that it is proteid. (*Plüger's Arch.*, lii. 125.)

Trambusti, experimenting with dogs, finds that as a consequence of the removal of the cœliac plexus, glycogenic and hyaline metamorphoses supervene in organs connected with the plexus (liver, kidney) and in these alone. The changes affect not

only the blood vessels, but also the cells of the liver and kidney, and depend upon an actual degeneration of the protoplasm, and not upon mere infiltration. The author further experimented with rabbits and dogs in order to ascertain whether these changes could result from acetone poisoning or inanition, as has been supposed. The experiments lend no support to this supposition. (*Centralbl. f. allgem. Pathologie*, Sept. 10th.)

Of the action of the unorganised ferments, one characteristic is, according to **G. Tammann**, the incompleteness of the degree to which they attack the material under fermentation. At the termination of their activity a greater or less quantity of the fermentable material is still unchanged. This is because (1) the ferments themselves are rendered powerless by the products of the fermentation; and (2) the ferments in solution themselves decompose, especially if the temperature be over 50° C. This incompleteness of action does not characterise the decompositions brought about by acids or by heat. Tammann discriminates "fermentations in homogeneous systems" from "fermentations in heterogeneous systems." In the former the fermentable matter and the products of its decomposition are both present in the solution from the beginning to the end. (Examples: Action of emulsin on amygdalin, æsculin, daphnin, coniferin; the inversion of cane-sugar by invertin and koyi.) In the latter the ferment either acts upon insoluble substances and produces soluble from them (salivary, gastric, pancreatic digestion), or produces from them substances partly soluble and partly gaseous or insoluble (clotting of blood, of muscle, of milk). The incompleteness of the fermentation can usually be changed into completeness by either removing the products of the action as fast as they are formed (as done by Kuhne in his experiments on the action of pepsin), or by adding a large amount of the ferment during the fermentation. In this way certain natural fermentations are complete in their results—*e.g.*, the clotting of milk by the gastric juice. With increase of the amount of ferment present, the proportion of the fermentable substance ultimately fermented is increased up to a certain maximum. Increase of the quantity of ferment also raises the degree of temperature which is best for the fermentation. But it must be remembered that the process of fermentation, of fermentive decomposition, includes three distinct reactions which proceed at very different rates. (1) That reaction which is hastened by the ferment—*i.e.*, that in result of which the fermentable material is decomposed. (2) That conversion of the ferment into a modification of it which is inactive. (3) The

decomposition of the ferment. So that it is clearly impossible to express in simple ratios universal laws for the speed, completeness, etc., of fermentations in general. It is only possible at present to find out empirically rules applicable to special instances. It is shown by Tammann for invertin and cane-sugar (and other workers have proved the same for certain other cases) that the speed of the ferment-action is increased by increase of the amount of ferment. With a unit quantity of ferment the initial speed of fermentation is greater in dilute solutions of the fermentable matter than in concentrated. When the ferment action is half-way through, its speed is greater in the concentrated solution than in the dilute. As regards temperature, it is remarkable that ferment actions disclose an optimum of temperature to which decompositions by acids, etc., are relatively indifferent. (*Zeits. f. Physiol. Chem.*, xvi., 271.)

Salvioli and **Albanese** have given two further contributions to the study of fatigue from Mosso's laboratory. Salvioli tired dogs by means of the turnspit wheel and investigated the gastric juice, a secretion of which he produced either by introducing indigestible material or by direct stimulation of the mucous membrane by means of a feather. He found that the fasting stomach contains no gastric juice, and that the secretion of the juice varies day by day. When excited by mechanical means the juice secreted contains not only free HCl, but all components essential for digestion. He also proves regarding the influence of fatigue on digestion that a tired dog apparently secretes little gastric juice, and this is of remarkably poor acidity, contains a smaller total of Cl than the normal, and has to a great extent lost the power to digest; but the passage of little bits of white of egg from the stomach into the intestine occurs more often in animals which are working than with those which are at rest. In the case of the first, the percentage of solid matters in the juice is lowered, but the quantity of mucus can increase so much as to often make the whole contents of the stomach. The normal condition returns after about two hours' rest.

From the investigations of the second author it appears that an extraordinary field of research is opened by the extirpation of the suprarenal capsules. Arguing from the already established fact, that death sets in earlier after extirpation of the suprarenals if instead of rest the animals are put to active movements, Albanese, after destroying the suprarenals in them, tired out frogs and rabbits by means of muscular work produced electrically. He found that those animals which were allowed to rest lived five or six days after the operation, but those which had to do muscular work

died the day following. The same results occurred both with frogs and rabbits, only with the latter the respiration was more altered. The rate of respiration became slower and shallower, the whole being accompanied by increasing cyanosis of the ears and a fall of temperature. With rabbits also, as with frogs, the heart was the "ultimum moriens;" it continued to beat two or three minutes after stoppage of the respiration.

If normal animals were tired in exactly the same way symptoms appeared which corresponded precisely with those at the commencement of that progressive paralysis which occurs in animals from which the suprarenals have been extirpated, but these animals made a quick recovery. The symptoms soon ceased to be very similar to those which occurred in animals from which the suprarenals had been removed.

The author in conclusion accepts the hypothesis that the suprarenal glands, under normal circumstances, destroy, or at least transform, a toxic substance which is formed in the body by the activity of muscles and nerves. (*Arch. Ital. de Biologie*, xvii. 248 and 239.)

Haldane and **L. Smith** have re-examined the question as to the nature of the toxic matter in air vitiated by respiration, and come to conclusions opposed to those recently brought forward by Brown-Sequard and D'Arsonval, but in harmony with those previously expressed by Pettenkofer's pupils, Hermans, Lehmann, and Jessen. The two French observers suppose that volatile poisons are exhaled with the breath, and can be obtained by condensing the vapour of the breath. Dastre and Loye showed, however, six years ago, that the injection intravenously of large quantities of pulmonary condensations is no more fatal than injections of distilled water. Haldane and L. Smith now show that the only toxic material in expired air is the carbonic acid. The immediate dangers from breathing air highly vitiated by respiration arise entirely from the excess of carbonic acid and the deficiency of oxygen, and not from any special poison. Hyperpnœa (exaggerated activity of the respiratory movements) occurs when air vitiated by breathing is respired. This hyperpnœa is due to excess of carbonic acid, and is not appreciably affected by the corresponding deficiency of oxygen. The hyperpnœa is apparent as soon as the carbonic acid rises in amount to 3—4 per cent. At 10 per cent. there is great distress. (The amount of CO_2 in healthy air is ·04 per cent.) Excess of carbonic acid is likewise the cause of the frontal headache produced by vitiated air. Hyperpnœa from defect of oxygen begins to be appreciable when the oxygen in the air breathed has fallen to a point which

seems to differ in different individuals, usually about 10 per cent. (*Jour. of Pathology*, i. 168.)

Muscle and nerve.

A. Maggiora, with the help of Mosso's ergograph, has investigated the effect of massage, under various conditions, upon human muscle. The hand is fixed in the apparatus, and to the middle finger is attached a weight. When the finger is exhausted by moving the weight the fatigue is traceable by the flexion curve, which itself can be estimated for comparative investigation. The fatigue produced in the muscles of the finger by lifting the weight a certain number of times in rapid succession is recorded graphically upon a registering surface over which a light lever attached to the weight travels.

Numerous tables illustrate the paper, the chief conclusion of which is that massage increases the working power of muscles. The action of massage is in proportion to its duration within short limits (about five minutes). The tired muscle recovers much earlier if it is massaged than it does if left to itself. Of the forms of massage, "Petrissage" proves to be more effectual than the "Percussion," and the latter is more so than the "Frottement."

Under stress of work, other organs than those directly involved suffer fatigue—*e.g.*, the limb muscles by excessive talking, and so on. In such cases the effect of massage on the tired muscle is shown distinctly. This is found with muscles which have been weakened by fasting and fever. The injurious effect of anæmia on muscle is by massage rather increased than diminished. These facts stand well in accordance with the view that apparently the good done by kneading a muscle rests on its furnishing more nutritive material to the muscle rather than removing from it products of muscular action. In the experiments the movements of the muscle of the finger were mostly voluntary, often also they were caused by faradic stimulation of the nerves, or by direct stimulation of the muscle. (*Arch. Italiennes de Biologie*, xvi., 225.)

Langley and **Anderson** have lately published an interesting paper on the mechanism of the movements of the iris—a subject which has been under discussion for the last fifty years. In all their experiments anæsthetics were used—rabbits, cats, and dogs being employed for the investigations. In giving a brief summary of the theories which have, with any plausibility, been put forward to explain the dilation of the pupil, they deal only with the effect produced by stimulating the sympathetic nerve, for that

lies at the root of the matter; and the view taken as to the dilation caused in other ways will depend on what is shown to be the cause of the sympathetic dilation. Some of the theories to be considered are:—(1) That dilation is due to the action of the sympathetic vaso-constrictor nerves. There are two ways in which the contraction of the blood-vessels of the iris, induced by the vaso-constrictor nerve-fibres, might cause dilation of the pupil —(*a*) by decreasing the quantity of blood in the iris so that it shrinks, (*b*) by a longitudinal contraction of the radial arteries of the iris—this contraction dragging the sphincter outwards. (2) That dilation of the pupil is caused by the contraction of radially arranged muscular fibres. (3) That dilation is caused by inhibition of the sphincter muscle. (4) It is possible that in certain circumstances some degree of dilation of the pupil might be caused by a relaxation of the ciliary muscle. By such relaxation the elasticity of part of the ciliary region and the anterior part of the choroid would come into play and pull the iris back. (5) Finally the dilation might be due to simultaneous action of more than one of the above causes.

The first part of the paper is a critical account of the experimental theories which have been given for and against the existence of a dilator muscle in the iris; and on reviewing the evidences of these theories as to the way in which the sympathetic causes dilation of the pupil, the authors find them to be inconclusive, and from their own experiments they draw the following conclusions:—For the dilator muscle it has been thought that the sphincter muscle is dead at a time when the cervical sympathetic nerve will still cause a dilation of the pupil. The rapid death of the sphincter has been shown by Brown-Sequard not to occur. That the occurrence of a local dilation of the pupil shows the presence of a radial muscle. It may, however, be produced by local contraction of blood-vessels, or by local inhibition of the sphincter muscle. That dilation of the pupil in rabbits may be obtained after removal of the sphincter. But this might be due to a contraction of the blood-vessels of the iris, or perhaps to a mechanical bulging of the lens.

Against the dilator muscle it has been urged:—That the ciliary portion of the iris does not contract with warmth like the sphincter portion; this is so, but the difference is only one of degree. That the sphincter can be made to dilate by direct stimulation, and that perhaps the sympathetic acts in a similar way and inhibits the sphincter. This conclusion is merely a probability, and direct proof of it has not been brought forward.

In favour of the dilation being caused in some other way than by action of the blood-vessels it has been said :—That on stimulation of certain nerves the contraction of the blood-vessels of various parts of the head does not occur synchronously with the dilation of the pupil, and that probably the blood-vessels of the iris contract simultaneously with the other blood-vessels of the head. The fact, however, is that contraction of the blood-vessels in the iris cannot be safely judged from the state of blood-vessels in the other parts of the head. That atropin causes dilation of the pupil without causing any constriction of the blood-vessels. But this does not show how the sympathetic causes dilation. From the whole of the previous observations there seems a probability that the sympathetic causes the dilation, not by producing a contraction of the blood-vessels, but partly by causing a contraction of the dilator muscle and partly by causing an inhibition of the sphincter muscle. The authors have made a direct examination of the iris during the stimulation of the cervical sympathetic, and it shows that the pupil dilates before the vessels contract; and assuming that the longitudinal muscular coat of the arteries contracts simultaneously with the circular coat, it shows that the sympathetic dilation of the pupil is not due to a contraction of the blood-vessels. Some radially arranged contractile substance exists in the iris, for when local dilation of the pupil passes a certain limit, the opposite side of the iris is dragged towards the stimulated side. This local dilation is not produced by an inhibition of the sphincter muscle, for that can be made to contract locally at the same time, its contraction being greatest at the most dilated portion of the pupil. Further, stimulation of the sympathetic causes shortening of a radial strip of the iris, isolated from the iris on either side of it, and this shortening may be obtained before or without any contraction of the blood-vessels in it; and on examination of the posterior surface of the iris small waves of contraction can be seen on it when the sympathetic is stimulated. Another proof of the absence of elastic tissue in the iris is that a radial strip does not always retract on being stretched, as it would do if it contained elastic tissue; and if the iris be left till its muscular tissue is dead, a radial strip of it does not shorten as it would if the sympathetic dilation of the pupil were due to elastic tissue pulling outwards an inhibited sphincter. The authors have not found that the sympathetic causes an inhibition of the sphincter muscle—it causes radial shortening of a portion of the iris without the least trace of relaxation in the tone of the sphincter border. Notwithstanding the proof that a radial contractile substance exists in

the iris, it is not yet satisfactorily settled that it is of the form of ordinary unstriated muscular tissue. (*Jour. of Physiol.*, vol. xiii., 554.)

W. P. Lombard has studied some of the influences which affect the power of voluntary contractions of the muscles. The experiments were carried on upon himself, and to test the suspicion that a preconceived notion had an influence on the result, he endeavoured before each experiment to make an estimate of the probable outcome. In this his failures were far more numerous than his successes; but although personally convinced that in this line of research his mental attitude had little or no influence on the result, for the sake of proving this to others he conducted his experiments in such a manner as to exclude as far as possible the influence of the mind. The work was accomplished with the flexor muscles of the second finger, and, except in a few cases, with the left hand. The arm rested on a support, the hand fixed by the insertion of the first and third fingers in closely-fitting tubes, and the placing of a firm cushion behind the knuckles. A collar of leather surrounded the second phalanx of the second finger, and connected it with a strong gut cord, which passed over a pulley to the weight attached. A weight of two kilos was used in all the experiments at the beginning, and later weights of three, four and five kilos were employed. The movements of the finger were traced on the smoked paper of a kymographion drum. The chief results obtained by the author were as follows:—If a muscle is contracted voluntarily, frequently, and each time it is made to raise a fairly heavy weight, the power quickly falls off, and in time the muscle cannot raise the weight. If, however, the weight is striven to be lifted, the power is periodically obtained again, more or less completely. The influences which are found to affect the voluntary power of the subject may be regarded as those controlling the activity and fatigue of the special central nervous mechanisms, which develop, or transmit, the voluntary impulse to the nerve-fibres that supply the flexor muscles of the second finger. Experiments which have been made with other parts prove that other similar mechanisms are affected in the same manner. The following influences were observed:—

(1) Those which lessen the power of performing voluntary muscular work, are general and local fatigue, hunger, falling atmospheric pressure (including the regular and irregular variations), high temperature (especially if accompanied with much humidity), tobacco.

(2) Those which increase the ability to do voluntary muscular work, are exercise, rest (especially sleep), food, increasing

atmospheric pressure (including regular and irregular variations), and alcohol.

The author found that exercise acts in the same way as sleep and food, and the effect of it shows itself in such a marked manner as frequently to disguise the action of other influences. While food and sleep act solely as restorers of strength, exercise increases the power. Sleep has a greater effect than food, and is more beneficial than rest taken when awake, probably because during sleep the restorative processes go on without opposition. Just as the power of activity is seen to be diminished by work done during the day, it is seen to be increased by the rest obtained during the night. As the experiments are proceeded with, the loss of power resulting from the work of each day is decreased; therefore the amount of strength gained by the night's rest is relatively lessened; but the influence of exercise, on the contrary, becomes more marked as the work goes on. Alteration produced by weather, although shown on several days, is sometimes subordinate to these influences; but if the subject does not sleep well, or his general condition undergoes changes, these facts would probably have an important effect. A rising barometer favours the influence of exercise, sleep, and food to increase the power, while a falling barometer opposes them, perhaps overcomes their effect and diminishes the strength. Tobacco acts vigorously, as does also alcohol. The former occasionally prevents the effect of a rising barometer or of nourishment exhibiting itself, and even appears to lessen the influence of exercise. Alcohol taken in small quantities increases the strength even when the barometer is falling. Therefore tobacco and alcohol are inclined to neutralise each other's effects, the action of one or the other being exhibited according to the strength of the dose. The influence of either of them is merely temporary, lasting but for an hour or two. These statements only refer to small doses of alcohol. Had large quantities of alcohol been taken it is possible that the primary strengthening influence would have been succeeded by depressing after-effects. (*Jour. of Physiol.*, xiii., 1.)

Chauveau, in making investigation of the sensorimotor "nerve-circuit" of muscles, holds it as probable that in the voluntary muscles the motor nerves are in direct continuity with the sensory nerves. The author decides, therefore, upon using the term "nerve-circuit," an expression which has already been employed by Charles Bell.

The muscle itself is not a member of the sensorimotor chain; the chain is made up of sensory nerves, sensory and

motor cells, and motor nerves. The muscular element only touches the circuit tangentially by means of the motor end plate. In the visceral muscles the peripheral connection between centrifugal and centripetal nerves is realised by the intra-muscular nerve plexus containing nerve cells.

Sensory and motor fibres to the musculus sterno-maxillaris (sterno-mastoideus) of the horse are, at a certain distance from the muscle, completely separate. The motor and sensory twigs unite to form the nerve trunk of the muscle.

Stimulation of the motor nerve when undivided, or stimulation of the peripheral end of the nerves when divided, evokes contraction of the muscles. Stimulation of the central end of the cut nerve gives no result. Weak stimulation of the sensory nerves causes reflex contraction, usually confined to the musculus sterno-maxillaris. To cause contraction of other muscles the stimulation must be somewhat stronger. Stimulation of the peripheral end of the sensory nerves when cut remained without effect. The sensory nerves of the muscle therefore form, together with the central nervous cells, a circuit in which the impulses always progress in the same direction till they meet the muscle and cause contraction. A weak stimulation of the sensory nerve is perfectly reflected on to the motor path to the muscle by the central cells; a strong stimulation of the afferent nerve on once reaching the central nervous system can here irradiate in many directions and bring other muscles into play.

Section of the motor nerve paralyses the muscle; section of the sensory nerve appears to have no effect on the voluntary power of the muscle, as well as none on its nutrition. The muscle, when deprived of its sensory supply for several weeks, still possesses a normal appearance to the naked eye and also to microscopic examination.

Claude Bernard, in his experiments in which the whole of the posterior roots of the lumbar nerves on one side were cut through, met with altogether different results. The voluntary movement was deeply injured after this operation. The motor disturbance could not be ascribed to interruption of the sensory paths of the cutaneous nerves, therefore must depend on destruction of the sensory nerves of the muscles. Chauveau cut all the sensory nerves of a pigeon's foot and a horse's foot without causing the slightest disturbance of progression. During sleep the pigeon operated upon stood as often on the foot deprived of its sensory nerves as on the uninjured foot.

In the gullet of the horse one finds an anatomical separation

of the motor nerve and the sensory also. The sensory fibres supply the muscles and the mucous membrane. The sensory fibres take no part in the act of swallowing—this is proved by section of the œsophagus and section of the nerves of the mucous membrane. Section of the motor fibres of both sides destroys the peristaltic movement of the muscles of the œsophagus. Section of one side alone does not interfere with the movement. Complete section of the sensory fibres causes injury—for instance, paralysis and ataxia of the middle of the lower portion of the œsophagus. Section of the vagus of one side does not always at once upset the act of swallowing. Later the act appears to be performed with difficulty. Tetanic stimulation of the peripheral ends of the motor fibres causes tetanic contraction of the muscles of the œsophagus. Stimulation of the central end is generally without effect. Yet the motor branches appear in some cases to contain sensory fibres. Very weak stimulation of the peripheral ends of the vagus nerve that has been cut by the section exercises no influence on the œsophagus. Very weak and short stimulation of the central end of the vagus nerve always causes a reflex "total tetanic" movement. Very striking are the results of section and stimulation of the central ends of the sensory branches, which supply the lower throat portion of the œsophagus. A completion of the whole "sensorimotor" circuit is an absolute necessity for normal movement of the œsophagus.

For details, and a theory of the cause of the variable results of section of sensory nerve fibres of a single muscle (musculus sterno-maxillaris), or the sensory innervation of complexes of muscles (muscles of the œsophagus, muscles of the posterior extremity), the original work must be referred to. The author goes on to relate his experiments on direct mechanical or electrical stimulation of the motor or sensory groups of ganglion cells of the medulla oblongata, and the spinal cord of the horse. In both cases a motor reaction in the muscles was observed similar to that which was alluded to before during stimulation of the peripheral, sensory, and motor parts of the "sensorimotor circuit of nerves." Abolition of the circulation quickly destroys the functional capacity of the sensory centre of the spinal cord, while the motor centres remain excitable for some minutes. Several examples are given of co-ordinated movements, which are induced by stimulation of sensory nerves in the spinal cord of the horse after removal of the oblongata medulla, movement of inspiration on stimulation of the rami intercostal perforantes. Also co-ordinate movements of

the posterior extremities, such as kicking, after stimulation of the sensory nerves of the foot. (*Mémoires Soc. de Biologie*, 155.)

Goltz records observations upon three dogs from which both hemispheres of the brain were removed. After recovery from the surgical effects of the operation, the animals walked and moved about in a normal fashion. One of them, kept under observation for a year and a half, wandered constantly restlessly about. At night sleep was enjoyed, rolled up in the manner usual with dogs. A loud sound, such as the blast of a bicycle horn, is required to break sleep; when awake, the same noise elicits a shake of the ear. A sudden light causes closure of the eyes and a turning of the head. To a pinch of the skin the animals react with a growl or snap, and if the foot is held the animal tries to escape much as a normal dog might do, but rather clumsily. If, as the animal stands quiet, one of its feet is moved into a slightly strained or uncomfortable position, the position is immediately corrected. If the dog is placed upon a table, in which a little trap door is cut, so that one foot is set upon the trap door, and if then the trap is slowly let down, the foot is allowed to sink with the trap a little way, but a little way only. If the dog in running about hurts its foot, it will afterwards limp for several days upon three legs. It is able, therefore, to co-ordinate movements that are quite unusual to it. At first the animals have to be fed; they cannot feed themselves. After some months they are able to help themselves, but to start the feeding each day it is necessary to dip the muzzle into the dish containing food. If a little quinine (bitter) be added to their meat and milk they reject it with expressions of disgust. The animals are absolutely wanting in the higher intellectual qualities. Of the barking of other dogs, the caresses and stroking, etc., of their master, they take no notice whatever. Although when food is put to the mouth they seize and devour it, food is never sought for. If the coat is drenched with water, the animal shivers, but never attempts to shake, lick, or dry itself in any way. The fore-feet, although used for progression, are never employed to steady a bone or piece of food, and there is no propensity to scrape the ground. The animals are absolutely devoid of memory. Whenever they are taken out of the cage to be fed they show signs of anger—they bark loudly, snap, and struggle in every limb, evidently never learning that they are taken out to be fed. Only very occasionally do they exhibit any signs of expression. If they are a longer time than usual without food, they run more quickly round the cage, put their fore-feet through the railings, and show

signs of impatience. The animals are also capable of movement, taking nourishment, the sense of taste, hearing, capable of using their muscles, and so on. For the rest they are in a complete state of imbecility. Only during feeding do they show any sensations of pleasure. They also appear to know when their appetite is appeased—after eating the usual quantity of food they always refused to take more. The symptoms of having had the brain removed remained observable mainly in the want of expressions, from which could be drawn conclusions as to reason, memory, and intelligence. When the animals were killed, it was found that the entire cortex of the hemisphere of the brain, with the exception of the lowest end of the temporal lobe, had been removed. The remaining piece was atrophied, and showed yellowish-brown "softening." Further, a part only of the basal ganglia were present, and these also were in a condition of brownish-yellow softening.

It is probable that in the pathological cases of extensive softening of the brain in man a similar condition is present, and that the most helpless imbeciles of the madhouse are devoid of cerebral hemispheres. (*Pllüger's Arch.*, li., 570.)

Luciani experimented on dogs and monkeys. Section of the cerebellum, so as to divide it into right and left halves, produces permanent impairment of all voluntary movement, accompanied by diminution of the elastic tonus of the muscles when at rest, and tremor, intermittent action, and uncertainty of the muscles when in activity. With time the symptoms abate, but do not disappear. Extirpation of the vermis of the cerebellum induces, after temporary increase of tonus of the muscles of the neck and fore-limbs, a condition of lessened tonus and weakness, especially marked in the hind-limbs. In the course of a year recovery, almost complete, ensues.

Complete removal of one lateral half of the cerebellum was followed at first by tonic rigidity of the muscles on the same side as the injury of the cerebellum, and by turning of the eyes to the side of the injury. Then followed weakness and loss of tonus on the musculature of the same side. Almost complete extirpation of the entire cerebellum induced, during the ten days immediately following the operation, tonic rigidity of the muscles of the neck and fore-limbs, and clonic movements of the hind-limbs. The eyes converged strongly. Holding the animal up by the neck caused general convulsions. Then for a month there succeeded weakness and loss of tonus, especially in the muscles of the neck and hind-limbs. The animal could not walk or stand, but could swim. In the course of a year

the animal had learnt to walk, but somewhat clumsily. Sensation and intellect remained intact.

The ataxy did not become more evident on closure of the eyes, as it does in the human subject. Luciani combined with the extirpation of the cerebellum, extirpation of Ferrier's motor areas of the brain, and was led from that combination to believe that the compensatory movements by which the animal, after removal of the cerebellum, learnt to correct his ataxia, were carried out largely by the motor areas of the brain. Luciani could not discover any localisation of function in the cerebellum—each portion of it seemed to possess the same qualities as the whole. He concludes that the cerebellum reinforces the energy of voluntary movement, that it reinforces muscular tonus, that it quickens the rhythm of the elementary motor impulses and fuses them to continual action.

J. N. Langley has recently published a paper on the origin from the spinal cord of the cervical and upper thoracic sympathetic fibres, with observations on the white and grey rami communicantes. He studies the origin of (1) the fibres causing dilation of the pupil; (2) the vaso-constrictor and vaso-dilator fibres of the head; (3) the secretory fibres of the salivary glands; (4) the accelerator fibres of the heart; (5) the remaining efferent fibres of the sympathetic region in question. The experiments were made on dogs, cats, and rabbits, all of which were anæsthetised.

When the animal was thoroughly under the influence of the anæsthetic, the spinal cord was laid bare for a varying distance. As a rule, two or three nerves were first exposed and stimulated, and then progressively the nerves above and below these were exposed and stimulated. The author first made observations on the origin of pupillo-dilator fibres from the spinal cord, and the results of the experiments are:—The lower cervical nerves in no instance give the faintest indication of action upon either pupil, the nictitating membrane, or the eyelid. The 8th cervical nerve, although stimulated with currents of varying strength and of varying duration, produces no effect on the pupil or the eye. One experiment shows that stimulation of the 1st and 2nd thoracic nerve causes a considerable, though slow, dilation of the pupil when the index of the secondary coil of the induction machine was at 15 centims. of the scale, and a rapid, complete dilation with all greater strengths of current, whilst stimulation of the 8th cervical nerve is without a trace of effect on the pupil whether the index of the secondary coil was at 15 centims. or at 0, or at any intermediate position. No dilation of the pupil is, as a rule, obtained by stimulating any spinal nerve below 3rd thoracic, but

in the cat it is possible that, in some cases and under favourable circumstances, a slight dilation of the pupil may be observed on stimulation of the 4th thoracic nerve. The nerve-fibres causing retraction of the nictitating membrane and opening of the eyelids have in the cat a more extended origin than the dilator fibres for the pupil.

The results of experiments on the origin of the vaso-motor fibres for the head are as follows:—(1) The 6th, 7th, and 8th cervical nerves cause neither contraction nor dilation of the vessels of the head. (2) The 1st thoracic nerve has a slight and inconstant effect in the cat; the effect is apparently greater in the dog. In cats, it may be distinct enough to be beyond question, or it may not be perceptible in the conditions of the experiment. (3) The 2nd and 3rd thoracic nerves cause complete and rapid constriction of the small arteries. In the cat the 3rd nerve has seemed to produce constriction rather more quickly than the 2nd. (4) The 4th thoracic also causes complete constriction, but more slowly than either the 2nd or 3rd; in the dog its effect is less than in the cat. (5) The 5th thoracic nerve has less effect than the 4th. In the cat the constriction caused by it, though it may be complete, is usually slow. In the dog the author has found no satisfactory evidence of the existence of vaso-motor fibres in the 5th nerve, but he thinks it probable that they are sparsely present. (6) The thoracic nerves below the 5th have not in the cat and dog any effect upon the vessels of the head. Langley finds no flushing of the bucco-facial region on stimulation of any one of the 2nd to 5th thoracic nerves, but the nerves which cause pallor in this region are the 1st to the 4th.

From observations made on the secretory nerves for the submaxillary gland in cat and dog, it will be seen that the 2nd thoracic nerve has a distinctly greater effect on secretion than any other. The 3rd thoracic nerve, in each of the experiments, causes some secretion, but in three of these several stimuli are occasionally necessary before a secretion is visible. It is probable that in most cases the 4th and 5th thoracic nerves in the cat contain a few secretory fibres. In the dog secretory fibres are found in the 4th nerve. With regard to the 5th, the evidence is not very clear, but there appear to be a few secretory fibres present. The 1st thoracic nerve in the cat gives very slight evidence of containing secretory fibres, and in most cases no evidence at all; in the dog, on the contrary, more or less satisfactory evidence is obtained. Therefore the origin of the secretory fibres in cat and dog is very similar to the origin of the

vaso-motor fibres in these animals—in the dog the secretory and vaso-motor fibres are more represented in the 1st thoracic than in the 5th, while the reverse is the case with the cat.

In his observations on the origin of accelerator fibres from the spinal cord the author finds that a similar state of things holds with these as with the secretory fibres. In one animal the 1st to the 4th thoracic nerves will always produce distinct quickening of the heart-beat, while in another animal the 1st for the 4th thoracic will be constantly without effect. The author thinks this is primarily due to varying responsiveness to accelerator impulses, and secondarily to a variation in the number of accelerator nerve-fibres in the corresponding nerves.

In investigations on the origin of other fibres of the cervical and upper thoracic region, the author and Sherrington showed in former experiments that, in the cat, the pilo-motor fibres for the cervical sympathetic arise from the 3rd or 4th to the 7th thoracic nerves inclusive. In the author's further experiments he has looked for the effect on the hairs. While the movements of the hairs on the face and upper vertebral area is always more or less distinct on stimulation of the 4th, 5th, and 6th nerves, Langley does not observe any second instance in which the 3rd nerve is effective. The hairs over the last two or three cervical vertebræ and the first one or two thoracic vertebræ are innervated by fibres which pass through the ganglion stellatum, and their exact origin is not yet determined. The author finds pilo-motor fibres in the dog in the cervical sympathetic, but so far, for the dorsal part of the neck only, and not for the face. They arise from the 4th, 5th, and 6th thoracic nerves; nerves lower than this the author has not yet tried. The 4th has less action than the 5th and 6th thoracic nerves.

In his remarks on the white and grey rami communicantes, the author goes on to say that, as there are two kinds, it must be considered whether the nerve fibres pass by one only, or by both of these communicantes. On examining the white and grey rami in dog, cat, and rabbit, Langley finds the uppermost white ramus to be in all cases given off by the 1st thoracic nerve. In one case the number of small medullated fibres in the rami of the 1st thoracic nerve were counted, and about 500 were found to be present. The medullated nerve-fibres which are present in the grey rami of the lower cervical nerves are either not efferent fibres, or they are too few to produce any perceptible effect. The 1st thoracic spinal nerve, the uppermost nerve which has a white ramus, is the uppermost nerve which on stimulation produces sympathetic effects.

Actual experiment gives very little support to the view that there are efferent fibres in the grey ramus. It is, however, most improbable that the large medullated fibres should be efferent fibres. Every visceral efferent effect can be attributed to small medullated fibres, and no single visceral efferent effect can, at present, be attributed to fibres above 4 m. in diameter. Further, the Pacinian bodies of the mesentery of the cat are supplied with fibres arising from the division of large medullated fibres.

The author concludes with the view that the medullated fibres of larger diameter than 4 m. which occur in the grey rami are efferent fibres entering the cord by the white rami, but are not for the most part fibres of general sensibility. It seems to him not improbable that the afferent fibres of general sensibility are not fibres of any given diameter, but he leaves this question for the present an open one for further consideration. (*Phil. Trans. Roy. Soc. London*, clxxxiii. 85.)

R. Ewald has recently made some most interesting researches on the end organs of the 8th nerve. For several years he has been working at this subject, and has carried out his experiments chiefly on pigeons. The results obtained by him add at least two new points of fundamental importance to what is already known on the subject, and these points are of wide application throughout physiological science.

The first point is this—that not only the apparatus at the end, but also the trunk of the 8th nerve (nervus acusticus) is excited by waves of sound. For instance, it is proved that animals in which both auditory labyrinths are entirely destroyed, react to waves of sound, when every other movement of air is excluded; this reaction ceases when the branches of the nervus acusticus left behind at the previous operation are destroyed.

The second point gained is—that apart from the functions of the auditory labyrinth related to statical sense, a relation exists between it and the entire musculature of the body, and also between each labyrinth and both sides of the body. This relation consists of an alteration on the tone of the voluntary muscles, and by this means are to be explained the abnormal and violent movements of pigeons from which the labyrinth has been removed, as has been already noticed by Flourers and Goltz.

For months after the operation pigeons appear to behave in a quite normal manner; that is, they sit in normal positions, show no signs of asymmetry of movement, and nothing which indicates giddiness; but if the eyes of a pigeon so operated upon are blindfolded, and the bird turned somewhat when held in the hand, the holder's own longitudinal axis being rotated, the animal

did not show any nystagmus, which every normal animal under the same circumstances would do. These animals also show a peculiar haste and restlessness; if they are put in a small cage they almost kill themselves by struggling; and when they finally appear tired out and rest, it is generally in a most uncomfortable position—lying somewhat on their backs with the head under the body, and with the feet grasping the crossbars of the cage.

Pigeons from which the auditory labyrinths have been removed can no longer fly—at least, they lose the power of doing more than fluttering about the height of a centimetre. Nearly all the muscles of these animals show a peculiar loss of tone, which shows itself, among other symptoms, with the following—that if the bird is held in the hand and swung freely backwards and forwards, the head hangs loosely from the shoulders and dangles to and fro like the head of a dead bird. At certain times the wing hangs loosely down in a manner never seen in the normal pigeon; the bird allows its head to be brought into the most abnormal position by weighting it.

Frequently pigeons which are bilaterally operated upon show great muscular emaciation. Pigeons operated upon on both sides first begin to eat some time after the operation; those from which one auditory labyrinth had been removed ate immediately. They show from the first increasing twist of the eyes and head, with corresponding pose of the limbs, and these disturbances again abate later. The animals also show asymmetrical disturbances of muscular tone.

Without being able to go into the valuable and full statement on the method of operation and the anatomical arrangement, it must be mentioned that the author succeeds in strengthening the theory that the vertigo caused by rotation depends on the function of the semicircular canals. He proves this by showing that stopping the semicircular canals with lead does away with the effects of rotation in each of the three planes of space. He has also investigated the effect of giving an artificial movement to the lymph at the end of each semicircular canal. This is done by introducing water into the auditory labyrinths through an india-rubber tube, or the endolymph is set in motion by pressure on the membranous canal. Electrical stimulation of the individual ampullæ give no definite reaction. Ewald always arrives at one result, which he considers as the result of stimulation of the entire auditory labyrinths. He finds that during stimulation by the electric current the head always turns from the kathode; if the electric current is reversed in direction, the head is also always turned in the opposite direction. The author considers the first

as the effect of stimulation, the last as due to the inhibition of the functions of the labyrinths of the ear.

In accordance with the view he holds, Ewald designates a portion of the labyrinths of the ear which serve for the hearing, the auditory labyrinths; the other portion as the tonus labyrinth, because it governs the tone of the muscles of the body.

It is not possible to go into the individual experiments and the arrangements from which the author infers that the movements and symptoms in virtue of which the pigeons from which the labyrinths are removed differ from normal animals, do not, as has been thought, depend on defect of the statical sense. On account of the dissimilar nature of the functions of the nerve which we, till now, have called the nervus acusticus, the author proposes to introduce the impartial name of nervus octavus. (*Nervus Octavus*, Stuttgart, 1892.)

F. W. Mott.—Mott's experiments lead to the following principal points of interest:—(1) Return of associated movements after complete destruction of the crossed pyramidal tract below the lesion. (2) That all sensory impulses do not decussate in the cord, they rather seem to show that certain sensory impulses—such as touch, the muscular sense, and localisation in space—pass chiefly up the same side, painful impressions up both sides. (3) The vaso-metor disturbances are on the same side as the lesion, and consist of vaso-dilatation, swelling of foot, and redness, with rise of temperature of the skin of the foot; but, as compared with the opposite side, fall of temperature in the popliteal space on the side of the lesion, due, no doubt, to paralysis of the muscles. (4) The degenerations above and below the lesion are limited to the same sides when the injury is perfectly unilateral. (5) Stimulation of the cortex cerebri on both sides some weeks or months after the hemisection had been performed, generally gave results which showed that the block in the spinal cord produced by hemisection still existed, though there had been a complete return of associated movements. (6) In one case, ablation of the leg area on the same side as the lesion in the spinal cord was performed many months afterwards. The results of the experiment can be placed under the following headings:—(1) Motility; (2) sensibility; (3) vaso-motor and temperature; (4) degeneration; (5) cortical stimulations. (1) Motility.—The return of movement in the paralysed muscles was dependent upon the extent of the bilateral associated action; therefore muscles that invariably act in conjunction with the muscles of the other side were hardly affected, and it was difficult to observe any paralysis of the thoracic and abdominal muscles after hemisection in the

dorsal, and even the upper cervical, region. With one exception, movement in the muscles of the leg returned to such an extent that the animal was able to run about, climb, and spring, etc., as well as the normal monkey. At the end of three weeks movements of hip and knee generally return on the paralysed side. The animal would never grasp the finger with the paralysed foot; the muscles on the paralysed side were somewhat flabby and wasted, but when examined microscopically after death, appeared quite normal. Sensory symptoms.—If a clip was placed on the paralysed foot of the animal, and one on the non-paralysed foot, even some weeks after the operation, the clip was always removed from the non-paralysed foot by the animal, but never from the paralysed foot, although means were adopted by which the animal could not possibly have seen the clips applied to its feet—sometimes while the animal was unconscious with ether, sometimes while its attention was distracted by food, etc. For days after the operation the knee-jerks are, as a rule, abolished, and eventually exaggerated, on the side of the lesion. Vaso-motor effects and temperature.—There was temporary vaso-motor paralysis on the side of the injury, which passed off completely within a week or two. The temperature of the popliteal space on the paralysed side was lower by 1°—3° than on the non-paralysed side. As movement returned in the limb on the side of the injury, so this difference diminished, until after some months there was hardly any difference in the two sides. The plantar surface of the foot of the paralysed side was always dry, somewhat swollen, darker, and hotter to the hand than the opposite foot. When the vaso-motor paralysis passed off, the plantar surface on the side of the injury became cooler to the feel, and registered several degrees less than the other side. The plantar surface of the foot is supplied with sweat glands and a large supply of cutaneous blood-vessels. Hemisection of the cord paralyses the vaso-motor nerves and the sweat glands, causing an increase of blood to the part and deficient elimination of heat by cutaneous evaporation of sweat, hence an increased surface temperature. After the vaso-motor paralysis has passed off, there is a fall of the surface temperature. The results of cortical stimulation of the brain may be summed up as follows:—On the side opposite to the lesion, the leg area of the cortex cerebri required a very strong current to produce any effect, and the movements were leg movements. Sometimes no effect was obtained, and as often as not movements of the leg of the same side were noticed. Where the section of the cord was made at the level of the third cervical, no movements could be

obtained except shoulder movements. The author remarks that the ultimate solution of the question rests upon an unbiassed record of the cases of disease and injury in man, and it is hoped that, by the help of microscopical research and physiological experiment, a correct understanding of the path of conduction and the functions of the spinal cord will be arrived at. (*Phil. Trans.* clxxxiii., 1.)

The same observer has re-studied some ascending degenerations resulting from lesions of the spinal cord in monkeys. It is known that the periphery of the lateral and anterior columns of the spinal cord in animals, such as rabbits, cats, dogs, and monkeys, is made up of fibres which connect the cells of the cord with the cerebellum. In one experiment a section of both antero-lateral columns was made in the mid-dorsal region. The next day after the operation the animal was tested and no loss of sensation was apparent. On the fourth day the weakness of the lower limb had passed off, and the animal behaved like a normal monkey. It was killed three weeks after with chloroform. There was extensive degeneration on both sides in the antero-lateral columns above the lesions, and also in the antero-lateral region below the lesion. Section of the right antero-lateral region of the spinal cord of the third cervical segment and lesion, was successful. Half-an-hour after the injury the animal had recovered consciousness, the pupils were equal, and both sides of the chest seemed to move normally. There was no vaso-motor paralysis, but the right arm and leg were partially paralysed. Microscopical examination showed that the cross pyramidal tract had been considerably injured. Section of the left posterior column, the posterior horn, and the posterior part of the lateral column was made between the first and second lumbar. The effect of this lesion, which extended for about a quarter-of-an-inch, was to produce weakness in the left foot and loss of localisation to a great extent. Examination of the cord showed above the lesion a scattered degeneration in both anterior and lateral columns which gradually became less and less as the cervical region was approached. At the level of the second cervical, the degenerated fibres in the ventral cerebellar tract of the same side were more than twice as numerous as on the opposite side to the lesion. The following conclusions may be drawn from these experiments:—The peripheral portion of the anterior and lateral columns consists of ascending and descending cerebellar fibres. The former may be divided into a ventral and a dorsal portion, which may be termed the ventral and dorsal ascending cerebellar tract, instead of antero-lateral and direct

cerebellar. The ventral portion may apparently be completely divided in monkeys without causing analgesia. The ascending cerebellar tract, consisting of ventral and dorsal portions, forms a connecting bridge between the superior vermis of the cerebellum and cells in the cord. The dorsal portion connects the cells of Clarke's column with the dorsal portion of the superior vermis. The ventral portion connects certain cells of the cord with the ventral portion of the superior vermis. Section of the antero-lateral column in the cervical region produces a much denser degeneration amidst the arciform fibres than can be accounted for by the slight injury to the direct cerebellar fibres. The very extensive tract of degeneration corresponding to the ventral cerebellar has been traced in monkeys to the superior vermis by way of the superior cerebellar peduncle, forming in its course a remarkable loop over the fifth nerve. Scattered fibres belonging to the fillet can be traced as far as the anterior quadrigeminal body of the same side. (*Brain.*, pt. ii., 215.)

L. E. Shore furnishes a contribution to our knowledge of taste sensation. The paper treats of the action of the leaves of Gymnema sylvestre on the sense of taste. The author worked with dried leaves of this plant, which is an Asclepiad, and grows in parts of India and Africa. It has recently been noticed that after chewing the leaves of this plant, sugar no longer excites a sweet taste. The leaves were extracted with water in a Papin's digester, and from the filtered solution a bulky precipitate thrown down by the addition of hydrochloric acid. After repeated washing, the precipitate was dissolved in alcohol, and the alcoholic solution decolourised by repeated boiling with animal charcoal. On concentration, the solution deposited a nearly white crystalline powder. The substance thus obtained is insoluble in water, so that its sodium salt was made and an aqueous solution of it used in many experiments. The author has confined himself to the effect of the drug on man. Many of the experiments were conducted on his own tongue, but the leading features have been tested on twenty-nine different persons. Tastes may be divided into four classes—sweet, bitter, acid, and salt—and Shore took an example of each in the following—glycerine, quinine sulphate, sulphuric acid, and pure sodium chloride all being employed in their watery solutions. The tip of the tongue is most sensitive to sweet and acid tastes. The power of perceiving bitter is much less than in any other region. In observing the action of gymnema on the taste of the above substances, the decoction has an acrid bitter taste on all tasting regions of the tongue, but not very strongly so even at the back.

This taste largely dies away as its application is proceeded with, and in about fifteen to thirty seconds a slight tingling sensation is experienced (probably due to resins or some other bodies present), but this quickly passes off, and then the further application of the decoction to the same spot produces no bitter taste. On investigating the action of gymnema on tactile perception, it was found to have no power to diminish either the discrimination of points or the perception of induction shocks. Two points may still be perceived when only 1 mm. apart, at the tip. Gymnema has no action on pain—the prick of a needle excites the same sensations. Touching, or rubbing different parts of the tongue and palate excite, in addition to tactile and general sensations, others which must be ascribed to an excitation of the nerves of taste. The sensations are not perceived till perhaps as long as five to ten seconds after the rubbing. The best marked is the bitter sensation at the back. This is not observed after gymnema. The action of gymnema on "electrical taste" is as follows:—The initial bitter taste perceived at the right edge and back in one case was cut off by gymnema, and in another case the bitter taste experienced at the back is entirely prevented—no taste at all resulting from weak shocks. Acting as gymnema does on pure sweet and bitter tastes only, this seems conclusive proof that the interrupted current has stimulated the nerve fibres or end-organs concerned with bitter tastes. Tactile perception is not so acute at the back. It is observed that as the strength of the shocks is increased the taste becomes more acid at the back after gymnema, and occasionally becomes salty and acid, when the individual shocks give rise to tactile impressions. General sensory impressions, smarting, burning, etc., as well as true taste, are absent when acids of moderate strength are applied to the dorsum of the tongue. It is only when the strength is so far increased that slight visible corrosive action on the epithelium takes place, that feeling is set up. The 1 per cent. solution, in which the acid taste is well marked at the tip, and not obscured by smarting sensations, produces perhaps slightly less effect, but the character is not changed. With stronger solutions no change in either component can be detected. No difference was detected after the application of gymnema. Experiments on the action of cocaine show that though it acts powerfully on general sensations, its action on acid taste is by no means very great. When acids in moderately strong solutions are applied to the tongue, the sensations excited are of two kinds—one called a true taste, but to be considered in a different way from the true tastes excited by sweet and bitter substances, and as rather a specialised form of

tactile perception; and other sensations due to excitation of nerves concerned with general feeling and pain. The conclusions the author draws as to the nature of salt taste are very similar to those given as to the nature of acid taste. Experiments show that, with cane sugar and grape sugar, however strong the solutions are, only pure tastes are excited. With glycerine, if the sweet taste of 50 per cent. solution be prevented, a slight burning sensation is produced at the tip. With strong glycerine the sensation is more marked. Gymnema removes the sweet taste of saccharine, and no sensations are then detected. Solid saccharine placed on the tongue is tasteless after the action of gymnema. With sulphate of quinine, after gymnema, a slight acid taste is noticed at the tip. The taste excited by extract of socotrine aloes is a pure bitter. Very dilute solutions of picric acid are intensely bitter at the back; after the action of gymnema even a saturated solution excites no sensation. Gymnema does not seem to have so powerful or ready an action on bitter as on sweet taste—the reverse appears to be the case with cocaine. The negative after-taste with alkalis is unfortunately not of a nature to be acted on by gymnema. It is detected, like the alkaline taste, as well after gymnema as before. The taste of a very large number of substances used in ordinary life are but little affected by gymnema. Only such bitter and sweet components as are present are removed. The action of gymnema is perhaps best explained by the supposition that the nerve-fibres or nerve-endings capable of being stimulated by pure sweet and bitter substances are different from those excited only by acid and salt. The selective action of cocaine also points to the multiplicity of the kinds of endings of sensory nerves in the tongue. The more powerful action of cocaine on bitter taste than on sweet, and of gymnema on sweet taste than on bitter, may also show that the nerve-fibres and nerve-endings concerned with these tastes are also distinct. The phenomenon of after-tastes between sweet and bitter sensations, points in the same direction. When bitter taste is absent at the tip of the tongue, sweet taste is very weak or absent also. The analysis of acid taste sensations, varying as they do in different regions, reveals their origin from two kinds of nerve endings, and the same is probably true of salt taste. Different tastes are excited by the same stimulus when applied to different parts of the tongue. A simple view to take is to consider that there are a number of different kinds of nerve-endings or end-organs scattered in varying density in different regions, and the taste excited by a substance, at a particular area, may be explained in one of the following

ways:—(1) By excitation of one kind of ending only, as is the case with substances of a pure sweet and bitter taste. If the particular kind of ending does not exist in the area, no taste is excited, as is the case when quinine is applied to the tip of the tongue in some persons. (2) By the excitation of the kind of ending which predominates in that area, overpowering the effect of stimulation of endings present in smaller number—for instance, sulphate of magnesia at the back of the tongue exciting bitter taste, but after the nerve-endings concerned are paralysed, a faint acid taste is manifest; by the excitation of several kinds of endings simultaneously, as with many acids and salts, such as lead acetate. The multiple character of the sensations can be shown by successively paralysing the different kinds of endings. (*Jour. of Physiol.*, xiii., 191.)

P. Kaiser's work upon the functions of the ganglion cells of cervical cord in the throat region is divided into three parts, of which the first is a comparison of the literature on the localisation relationship in the cervical cord, and on the distribution of the nerves contained in the brachial plexus.

In the second part the author's method of research is explained, and further, in a clear and full description, the arrangement and the micro-chemical relation, the number and size of the ganglion cells in the spinal cord of man (adult, child, fœtus), and monkey (gorilla, according to Waldeyer, eroceleus sinicus), together with other animals whose anterior extremities are used in very different ways, *i.e.*, insect-eaters (hedgehog, shrewmouse, mole), cheiroptera (Plecotes auritus), and in rabbits, at different periods of life.

The third part contains the results of observations upon the relative number and size, as well as the micro-chemical qualities of those ganglion cells of the cervical cord which are concerned in the movements of the arms; in this way he hoped to determine the functional significance and importance of the groups of cells in the cervical region of the cord.

The spinal cords were hardened in Müller's fluid, cut in series 20 mm. thick, and afterwards stained brown by the author's naphthylamin method (*Zeits. f. Med.*, vi., 1889). The counting of the ganglion cells in the segments of the cord was undertaken, and the smallest and largest number of each counted cell group ascertained in the same manner, and in the same way the average diameter of the largest and smallest cells was determined both for length and breadth. The grouping was dealt with partly according to Waldeyer's division of the cells of the anterior horn (medial, anterior, and lateral), cells of the medial horn (central cells

and cells of the lateral horn), and the cells of the posterior horn (basal, marginal, and central) Partly they were divided by their affinity for naphthamine-brown into chromophile (dark brown), chromodect (tint of the grey substance), and chromophobe (uncoloured). These distinctions come out still more clearly when the field is but dimly lighted. The results of these individual observations are synoptically represented by numerous tables and curves, illustrated in twenty-nine diagrams. The whole work ends with the following conclusions: the number of the ganglion cells of the spinal-cords is in proportion to the complexity and fineness of the movements. The energy of the movements stands in direct proportion to the number and size of the ganglion cells. Nevertheless no simple relationship is discoverable between the two. The cervical region of the spinal-cord contains the following groups:—(*a*) the nucleus of the muscles of the back extends as a medial column through the whole length of the spinal-cord; (*b*) the nucleus for the spinal accessory nerve lies lateral to the former, and extends from the bulb to the sixth or seventh segment; (*c*) the nucleus of the phrenic nerve is found in the third to the fifth or sixth segment between the two first groups, besides which there are fibres of the phrenic nerve given off by the medial posterior group; (*d*) the nucleus of the nerve to the upper limb lies laterally, beginning in the fourth, more rarely in the third segment behind the group for the accessory nerves, and extends to the first or the second dorsal segment. The proximal half is divided into several which innervate the muscles of the shoulder girdle, the flexors and rotators of the shoulders, as well as the muscles of the radius. The distal half is divided into an anterior and a posterior part: the former innervates the adductors of the upper arm (*i.e.*, the pectoralis, latissimus, and teres major), and the triceps, the latter the flexors and extensors of the finger, muscles of the ulna, and small muscles of the hand. The author renounces, except as a suggestion, his belief that chromophobe cells in the spinal cord are especially to be found where it is a question of acquired automatic functions; they have obviously at their disposal a far greater stock of power than the chromophile cells. The greater their subjugation to the activity of the brain, the stronger they are in chromophil. (*Gekrönte Preisschrift*, Hannover, M. Nyhoff.)

Sherrington has examined the arrangement of the motor nerve-fibres in the lumbo-sacral plexus. His investigation was made chiefly upon the plexus of one species of monkey (*Macacus rhesus*). His paper is a long one, and only certain parts of it can be noticed here. He finds that individual variation of the distribution

of the several spinal nerves occurs with great frequency in the plexus of all the species he has examined. That is to say, the muscles which are supplied with nerve fibres from a certain spinal nerve root in one individual, in another individual may be supplied with fibres from the next spinal nerve root in front or behind that. The latitude of variation is not very wide, but its frequency of occurrence is great.

Most of the muscles in the limb are furnished each with motor nerve fibres from three spinal nerves, a few from two only. When the supply is triple it comes chiefly from the middle root of the three. The motor outflow of fibres for each muscle is spread in an unbroken fashion over a certain considerable length of the cord. In the great majority of cases muscles innervated by the same nerve root lie adjacent one to another, so that a continuous sheet or band, or ray of muscular tissue, is supplied by the same nerve root. The commingling of the motor fibres to various muscles is great even at their very exit from the cord. Each of the natural rootlets of the root consists of an aggregate of fibres, often representing, as far as the skeletal muscles are concerned, all the groups of nerve fibres contained in the entire root. The individual bundles of the anterior root are in miniature the entire root itself, and give results in quality broadly the same as does it, although not in quantity. This commingling of nerve fibres of different destination at their very exit from the cord points to a probability of their sources of origin within the cord being also commingled in the transverse plane of the cord, if not in the longitudinal. The region of outflow of the efferent fibres to a group of muscles, or the representation of a particular movement at a joint, often ends not conterminously with the spinal segment, but somewhere within the spinal segment, either overstepping or falling short of the anatomical limits of the segment. If each of the main movements of a joint, *e.g.*, flexion, extension, etc., be considered individually, the region of representation in the spinal roots is as long in the case of the small joints of the toes as it is for the hip or knee. The region of outflow for any main movement extends into at least three segments of the cord. Yet the total region of outflow for movement at the hip is longer than for movement of any other joint in the lower limb. This is due to the *flexion* outflow being more separated from the *extension* outflow in the case of the hip than in the case of the other joints, especially than in the case of the joints of the digits. The spinal centres for extension of the hip and for flexion of the hip overlap each other very slightly, but those for flexion and extension of the digits overlap each other very largely.

Of the opposed movements of joints the one directed towards the anterior aspect of the limb has always a spinal representation more anterior in the spinal nerve roots than is the representation of its fellow movement of opposite direction. The root districts (that is, the region of distribution of the spinal roots severally) intermingle and overlap each other more in the muscles of the hand and foot than in the muscles of the thigh and shoulder. It is, however, improbable that any one muscle fibre is supplied by nerve fibres from two separate spinal roots.

The experiments did not yield evidence that the movements which result from excitation of the individual roots of the brachial and crural plexuses are really highly co-ordinated and combined for a functional purpose. All the evidence went to show rather that the arrangement of the motor roots of the limb plexuses has an anatomical significance based on the segmental structure of the body, and not a teleological dependent on supposed demands of functional co-ordination. The limb in the light of its nervous supply must be considered an organ of segmental structure, that plastic, like the rest of the body, has been moulded by variation and by function, but not so rudely as to seriously obscure its segmental plan. The relation of the muscles of the limb to the cell groups in the spinal cord is discussed, and from experimental and other evidence it is concluded that the nerve fibres innervating the small muscles of the sole and palm spring from the postero-lateral cell-group of the anterior horn of the spinal cord in the lumbar and brachial enlargements of the cord. It is also pointed out that the nerve fibres causing dilatation of the pupil probably spring from the cells of the lateral horn of the spinal cord in the highest three thoracic segments. The segmental position of the motor nerves of the anus, vagina, urinary bladder, round ligament of the uterus, and the vas deferens is ascertained for each of these structures. Also the discovery of centres in the cortex of the brain for the movements of the anus and vagina is announced, and the localisation of these centres figured. It is pointed out that the action of a cortical centre can be *reversed* in the case of the small joints, such as the thumb, by section of the nerve supplying the muscles preponderating in the movement. Thus if by excitation of a spot of the cortex cerebri flexion of the thumb is being produced, and if then in the limb the nerve to the flexor muscles of the thumb be severed, the excitation of the cortex immediately produces extension of the thumb, showing that in the previous flexion both the flexor and extensor muscles of the thumb were being co-ordinately employed.

The "knee-jerk" is shown to depend upon the integrity of chiefly

the vastus internus muscle, and of motor fibres to it coming from the 4th and 5th lumbar spinal nerves (the 3rd and 4th of man). Also upon the integrity of the sensory or posterior spinal root of the 5th lumbar nerve (the 4th of man).

It is shown that the urinary bladder of the cat and monkey exhibits constantly a rhythmic "beat," and, like the heart of the frog, will go on beating steadily for some time after its complete removal from the body, if kept moist and at the temperature of the blood.

The distribution of the motor nerves to the skeletal muscles of the limb points to the limb being composed of a number of rays placed at right angles to the longitudinal axis of the body and parallel with the long axis of the limb. The most posterior of these muscular rays are the longest ones, and the most anterior the shortest ones of the limb series. The prominence of the limb from the body is of such a form that the anterior edge of the prominence is thrust out less abruptly than is the posterior. The posterior edge is occupied entirely by one muscular ray, the last or hindmost. Into the anterior edge enter a number of rays. Taking seven to be the number of rays in the hind limb of M. rhesus, along the whole length of the posterior border from the free distal end of the limb to its attached base runs the seventh ray, while into the anterior border enters each of the most anterior five of them. (*Jour. of Physiol.*, xiii., 621.)

BACTERIOLOGY.

By C. S. SHERRINGTON, M.A., M.D.

General.

Shattock has made an important series of experiments upon the alkaline fermentation of urine. In certain diseases the urine becomes alkaline when still within the body, just as it does by putrefaction when exposed for a sufficient time to the air after being voided. The alkalinity developed is irritating to the mucous membrane of the bladder, and is caused by the hydrolysis of urea with the evolution of NH_3. Surgeons have believed that the alkaline fermentation, when it occurs within the body, is due to the same innocuous bacteria as decompose it when exposed after being voided. Shattock has enquired whether the change can be induced by the microbes which cause suppuration and inflammation. He shows that pyococcus aureus, pyococcus

albus, and streptococcus pyogenes bovis, and hominis, some of the commonest bacteria causing inflammation and suppuration, will decompose urea with the production of ammonia. He also demonstrates that when the urine contains albumen, as it does when the mucous membrane is inflamed, these bacteria grow more rapidly, and produce from the proteid matters in the urine irritating and toxic substances that are more harmful than the ammonia. Under these conditions the common Proteus vulgaris will grow in the urine and infect it with putrid as well as ammoniacal compounds. The antecedent inflammation will be thus enhanced, the proteid thereby increased in amount, and its decomposition will further increase the inflammation. (*Trans. Pathol. Soc. of London*, xliii., 200.)

Some interesting investigations are made by **Theodor Geisler** on the effect of light on bacteria. The importance of sunlight for the health of mankind has long been known to medical men; therefore it is not without reason that with the present knowledge of hygiene it should be considered of great importance that light be allowed free access to dwelling-houses. Investigations have already shown the favourable influence of sunlight penetrating the sick-room upon the course of disease, even where the remaining hygienic conditions have been unchanged. In regard to this point, observations on the effect of certain coloured rays are of the highest interest. It seems only natural that these investigations should arouse the idea that sunlight can be made of therapeutic use, and also that where sunlight is not sufficiently strong, or does not exist at all, electric light might be made to answer the same purpose. The complete solution of these questions is at present impossible, and belongs to a more or less remote future; but we possess something towards the elucidation of the questions in the effect of light on bacteria, which has been closely studied. The author chiefly examines the effect of electric light and sunlight on typhoid bacilli, and he finally draws the following conclusions:—

(1) He cannot observe a qualitative difference in the effect of sunlight or electric light on these bacteria, merely a quantitative difference; for instance, sunlight had strong restraining effect on the development of the typhoid bacilli and electric light had also. (2) Not only are the luminous and chemical rays of both sunlight and electric light injurious to the growth of the typhus bacilli, but also the heat rays. (3) All rays of the electric and solar spectra, the red ones excepted, restrain the growth of the typhoid bacilli; the

restraining effect is stronger the greater the refrangibility, or the less the wave-length of the ray is. (4) The unfavourable effect of electric light and sunlight on the growth of typhoid bacilli in gelatine is partly through the effect of light on the bacillus, partly an effect on the soil in which it grows. (*Centralblatt f. Bakt. und Parasitenkunde.*, xii., s. 161.)

Le Dantec has made researches on symbiosis of algæ and protozoa. It has long been known that chlorophyl is found in the bodies of certain of the lower animals, and the question whether this chlorophyl belongs to the animal cells alone or to vegetable organisms has often been discussed by Brandt, Geza-Entz, Beyerinck, Famintzin, and Lankester. Le Dantec has shown that it is a question of symbiosis with an alga.

A great quantity of ciliata of the same species, Paramæcium Bursaria, were kept for a long time in two separate reservoirs, and of those enclosed in one under otherwise quite similar circumstances, some were altogether free from chlorophyl, others were completely green. If specimens were taken from both tanks and put into a small vessel, all the individuals showed themselves possessed of chlorophyl. In order to show that this is not due to the extinction of the variety free from chlorophyl by the other, but is due to direct infection, the author put some free from chlorophyl under the microscope, in water taken from the other tank, but carefully filtered so as to contain only débris of the green paramecia. When examined, these paramecia soon showed a certain tinging of green, and the multiplication of the parasitic alga could be seen. When kept in the dark the green paramecia turned brown. Placed ágain in the light, some of the paramecia became green again. (*Annal de l'Institut Pasteur*, No. iii., 190.)

A. Ebers, writing on glanders, says that one of the chief difficulties attaching to stamping it out is the difficulty of recognising the disease in its earliest stages. Koch's discovery of tuberculin, and its employment for the diagnosis of tuberculosis, awakened the idea of employing in a similar way a product of the bacillus of glanders. An extract has been prepared from the bacillus mallei, by means of which the diagnosis of the disease in doubtful cases is assured. Kalmy was the discoverer of this preparation, and his mode of extract was as follows: Taking five grammes of a pure culture of bacillus mallei, he added to it 20 cub. cent. of sterilised distilled water, and placed the mixture in the thermostat at 120° C. for twenty minutes. He repeated this heating process four times in forty-eight hours, and then left the mixture another forty-eight hours

in the thermostat at 39° C. He then filtered the mixture through a porcelain filter under pressure, and thus obtained 12 ccm. of a clear yellow liquid, which was again exposed for fifteen minutes to a temperature of 120° C in the thermostat. This liquid was used for subcutaneous injection in the horse, one cub. cent. being used for each of five horses. Of the five animals two were sound, two were manifestly glandered, and the fifth was inoculated with glanders at the same time as it was given the subcutaneous injection. During the next twenty-four hours, in the sound horses the injection caused no noteworthy rise of temperature, in the other three the temperature rose in the first thirteen hours from 38·5, 38·0, 38·6, to 40·5, 40·7, and 41·3° C. *Post-mortem* examination of these three animals left no doubt of their all being glandered.

In a similar way Preusse, veterinary surgeon at Dantzic, attempted the preparation of an extract of the glanders bacillus. Preusse used for this purpose old, dried-up cultures of the bacillus mallei grown on potato; these he steeped for several days in a mixture of water and glycerine (equal parts), at the temperature of the body (38° C.). The extract he filtered several times, and sterilised in the steam bath. It was finally an imperfectly clear, dark yellow, oily liquid, of neutral or faintly acid reaction; it possessed a characteristic odour. Preusse tried the action of this extract first of all on guinea-pigs he had inoculated with glanders. Later in the year he tried it on six horses belonging to certain large stables in which glanders had just previously broken out; none of the six horses, however, showed at the time of his experiments any unequivocal sign of being themselves glandered. The result of the trial on the horses was most striking. In five of them a considerable increase of temperature occurred, the maximum being attained about fifteen hours after the first injection, about eight hours after a second; the rise amounted to as much as 2·2° C. In the case of the sixth horse—a young foal—a rise of temperature amounting only to 0·5 C. ensued seven hours after the first injection, and no perceptible rise at all followed the second. The first five horses on the succeeding day showed lassitude; the foal was as well as it had been previously. *Post-mortem* examination of all six was made twenty-four hours later. Unmistakable evidence of glanders was discovered in the first five horses, but not in the young foal. The next trial was performed on a horse known to be sound; it was inoculated on three occasions with extract of the bacillus, and each time the temperature remained within the limits of health for the forty-two hours following the injection. In a horse showing manifest symptoms of the disease

the rectal temperature ran up 1·5° C. nine hours after the first injection, and more than 2° C. after a second.

In the military veterinary school at Berlin a somewhat similar investigation has been pursued by Pearson, who cultivates virulent growths of glanders bacillus in glycerine-peptone broth at 35° C., and when the rich growths thus obtained are fourteen days old, kills the bacilli by exposure to 80° C. for several hours, and then filters off the fluid through a porcelain filter. The clear fluid thus obtained is sterilised on three successive days by twenty minutes' steaming. This sterilised extract he has tested on healthy and glandered guinea-pigs in doses of 0·25 to 2·0 cubic centimetres. He finds that in the healthy animals this dose causes a mere trace of local reaction, and must be increased tenfold to produce febrile disturbance. But in the glandered animals even a quarter of a cubic centimetre causes the local symptoms of swelling and redness, and a well-marked febrile reaction.

Pearson's published experiments are less numerous and detailed than are those of Preusse. With Preusse's mallein observations have been repeated by Heyne, Schilling, Peters and Felisch, Dieckerhoff and Lothes, and by Walter. Subcutaneous injections of mallein have been employed by the six first named of these upon, in all, 64 horses. Of the 64 one animal was obviously at the time of injection glandered, but the remaining 63 showed at that time no definite symptoms of the disease. In 41 of the horses a first injection of mallein was followed in about eight hours, and a second in about four hours, by an elevation of temperature altogether above the limits of the normal. In 23 horses no rise of temperature whatever followed the injection. Every one of these 23 cases proved on *post-mortem* examination to be completely free from anatomical signs of glanders. Of the 41 horses which gave a febrile reaction after injection, 38 were found by *post-mortem* examination to be actually glandered, but in 2 of the 41 the most careful scrutiny failed to reveal any signs at all of a glanderous condition. In the remaining case one suspicious nodule was discovered in the lung, but did not prove infectious in a guinea-pig inoculated from it.

It is found that 0 5 cub. cent. of the mallein diluted with 5 cub. cent. of 1 per cent. aqueous carbolic solution is the medium dose of Preusse's mallein suitable for an adult horse. More recently still Nocard has prepared a mallein with which encouraging results have been obtained at the Pasteur Institute, Paris. There it has been tested on a large number of animals from omnibus stables. Of this extract undiluted, "malleine brute," the dose is rather less than the dose recommended for "mallein

Preusse." At the Brown Institution, London, mallein furnished by Roux, of the Institut Pasteur, as well as some prepared by Sherrington at the Institution, has for some time been under trial. The results at present obtained have not been altogether so thoroughly satisfactory as those reported from Dantzic; but the number of cases in which the trial has been made is at present insufficient to afford basis for a positive opinion. (*Ueber Rotz-lymphe. Centralb. f. Bakt. u. Par*, 1892.)

Cunningham has studied the normal behaviour of milk towards bacteria in general, and also towards bacilli, especially the "comma" bacillus of cholera, to which pathogenic properties are definitely ascribed.

He especially bestows great attention on the properties of milk in the condition in which it is generally used, and the investigations are principally made on milk as it is used in European houses and in the native bazaars in Calcutta, and are carried out on specimens which have been carefully preserved against contamination, some of which are boiled, and some sterilised.

The results obtained by the author are as follows :—

(1) The milk generally used in Calcutta contains a great number of bacteria, in some cases a most prodigious number.

(2) The number of definite species is nevertheless very small.

(3) All the species, the bacillus subtilis excepted, when boiled in the fluid a short time are destroyed.

(4) A certain small number of spores of the bacillus subtilis as a rule still exist after boiling, and these cause a prodigious development of this species in the boiled milk.

(5) Fermentation and curdling appear very quickly in unboiled milk.

(6) These phenomena are connected with the process of rapid development and increase of the bacteria which are destroyed by simple boiling of the fluid, and therefore in many cases do not occur in boiled specimens of milk.

(7) In certain cases, however, boiling, which destroys the bacteria in milk, with the exception of the bacillus subtilis, does not succeed in hindering fermentation and curdling.

(8) This depends on the fact that specimens which are taken from the upper layer of the milk show a much greater tendency to ferment and curdle than do specimens taken from the deeper layers.

(9) The cultures show no difference in the nature of the bacteria existing in the two layers, and no important difference in regard to their number.

(10) This phenomenon is, therefore, probably to be explained by a greater accumulation of the ferment produced by the growth of the bacteria in the upper layers, or probably perhaps as the result of a special accumulation of those components in milk which ferment, and in fermenting lead to alteration in the reaction and to coagulation.

(11) A modified "curdling" occurs in milk which has been deprived of all living bacteria, with the exception of the bacillus subtilis.

(12) This, however, is distinguishable from the usual "curdling" occurring in unboiled milk, in that it is independent of the development of acid in any remarkable quantity, and that, instead of forming a big thick mass such as common coagulation does, it consists of a fine powder-like precipitate.

(13) The methods which suffice to ensure sterilisation of milk differ somewhat in different cases in accordance with differences in the condition of the bacilli at the time. Methods which ensure sterilisation if no spores are present do not necessarily ensure it in the opposite case.

(14) Complete sterilisation can be certainly obtained by keeping the milk at the temperature of boiling water. For some hours the fluid continues to remain unchanged apart from condensation due to evaporation.

(15) The milk commonly used in bazaars and European houses in Calcutta is not a favourable medium for development of the comma bacillus, or even for its continued existence.

(16) The introduction of the comma bacillus into the milk does not prevent the normal prodigious increase of common bacteria of milk and the accompanying fermentation; and with the advance of the latter, the comma bacilli quickly cease to increase, and die down; so that under ordinary circumstances in twenty-four hours the milk contains no more living organism of this species.

(17) If, however, comma bacilli are introduced into milk which has been allowed to boil a short time before, they—for a time, at least—will in every case increase very rapidly.

(18) The presence of the comma bacillus appears in these cases at times to exert a repressive influence on the development of the bacillus subtilis.

(19) The repression is, however, only temporary, and the bacillus subtilis again appears in great abundance.

(20) The renewal of the bacillus subtilis is often united with pronounced decline of the power to increase, or even with entire suppression, of the comma bacillus; yet in other cases both species

could subsist close together in a similar medium for several weeks.

(21) Sterilised milk offers still more favourable conditions than boiled milk to the development and growth of the comma bacillus, apparently because the former is screened in the struggle for existence. (*Arch. f. Hygiene*, xii. 133.)

On the occasion of an epidemic of relapsing fever breaking out in Kief in the summer of 1890, **Soudakewitch** undertook to study the question of the fate of the spirilla in monkeys deprived of their spleen. Metschnikoff had already concluded from investigations he had made on monkeys with relapsing fever that the spirilla which disappear from the blood at the conclusion of the attack all accumulate in the spleen, and there are taken up into phagocytes. Six animals were placed at Soudakewitch's disposal at Kief. He first injected four monkeys, in which the spleen was not extirpated, subcutaneously with relapsing-fever blood containing spirilla, in view of repeating Metschnikoff's experiments. The animals reacted most on the third day, with a considerable rise of temperature (41—42°) and a large quantity of spirilla in the blood. So soon as the temperature fell the number of the latter speedily diminished, and then three of the animals were killed by chloroform. Immediate examination of the blood from the large vessels of the first animal revealed numerous phagocytes containing spirilla in a degenerated condition; no spirilla were here found in the spleen, but many were found in the spleen of the second animal, and in the spleen exclusively in large quantities. In the third animal neither in the blood nor in the spleen could distinct spirilla be shown to exist. In the first animal all the organs (liver, marrow, brain, etc.) contained spirilla, but always in the bloodvessels only. In the second animal they were found exclusively in the malpighian bodies of the spleen, and always in the interior of microphages. The organs of the third animal contained no spirilla, or at most mere remnants of them.

The author then commenced inoculations on two monkeys which had been deprived of the spleen. The first animal made a good recovery in eight days, at the same time as a control animal which had not been deprived of its spleen, but had similarly been inoculated with 5 ccm. of relapsing-fever blood. After three days the temperature of the control animal rose, and the spirilla appeared in the blood; in the case of the monkey which had been deprived of its spleen the spirilla also certainly appeared on the fourth day, but its temperature was strikingly low (34·8° in the morning, 37·2° in the evening), and so it remained on the

following days. Up to the eighth day the quantity of spirilla in the blood rose gradually, and the animal succumbed with a temperature of 34·7°, while the normal control animal made a complete recovery from a moderate fever which lasted three days. In the animals which had been deprived of their spleen the vena cava inferior was found at death to contain many spirilla; they were at least as numerous as the red corpuscles. In part they appeared in star-shaped heaps joined together in hundreds (as already observed by Heydenreich in human subjects). The film preparations never showed phagocytes, but only free spirilla. Contrary to this, however, the accessory spleen exhibited the most varied instances of phagocytosis and microphages, whose protoplasm was quite filled with spirilla partly in decay. The second monkey, from which the spleen had been removed twenty days after the extirpation, from which it made a good recovery, was inoculated with the blood of relapsing fever, and five days afterwards the spirilla appeared in the blood. As with the first animal, the temperature rose higher, not, however, exceeding 38°. On the ninth day after inoculation the animal died, with extreme increase of spirilla in the blood, and a temperature of 34·9°. In the blood and marrow phagocytosis was nowhere, or only quite exceptionally found. The author explains these results as a corroboration of Metschnikoff's theory, which, contrary to Baumgarten's contention, can be well demonstrated in relapsing fever. The animal deprived of the spleen forms a favourable ground for the culture of spirilla; these multiply unhindered without the glands, liver, marrow, or the vascular endothelium being able to defend the animal against the parasites. That an animal without its spleen is less able to resist certain kinds of infection cannot be doubted, the author thinks, after the results obtained by Bardach and these new ones. But that the want of splenic phagocytes is the explanation remains still an open question. (*Annales de l'Institut Pasteur*, No. ix. 545.)

Kenthack has recently investigated the question of whether the spleen is of importance in rendering rabbits immune against the bacillus pyocyaneus or not. Tizzoni and Cattani have shown that, under certain circumstances, it is impossible to confer immunity against tetanus on rabbits from which the spleen has been extirpated. As regards tetanus, therefore, we conclude that the spleen is the seat of the formation of antitoxic substances—if not exclusively, at least in a high degree. Now tetanus is the very type of a disease produced by an intoxication, therefore one must be careful not to think that all that happens with this disease will hold good for other bacterial

infection. It is therefore of great importance to discover if extirpation of the spleen prevents one being able to confer immunity from infectious diseases which depend in a less degree on intoxication than does tetanus. To do this the author made experiments with the bacillus pyocyaneus.

(1) Rabbits from which the spleen had been extirpated were, together with other normal animals, treated according to various methods of conferring immunity. (2) Rabbits were rendered immune against infection, and afterwards the spleen was extirpated. (i.) Three rabbits from which the spleen had been removed one or two weeks previously were, by means of subcutaneous injection, treated with filtered pyocyaneus culture (5 ccm.). They were proved to be completely immune against infection from pyocyaneus; 2 ccm. of very virulent culture being injected into their veins had no effect upon them. There appeared to be no difference between the normal animals and those from which the spleen had been extirpated, when treated in this way; in both cases they were rendered immune. Control animals always died twenty-four hours after intravenous injection. In other cases, after removal of the spleen, immunity was conferred by subcutaneous or intravenous injections of small, not fatal, doses of virulent cultures. In these cases also the results were the same; the extirpation of the spleen exercised no influence on the rendering immune against pyocyaneus infection, whatever way the conference of immunity is brought about. Bouchard and others have shown that the blood-serum of a rabbit which has been rendered immune has a destroying effect, arrests the growth of the bacillus pyocyaneus, and does not lose this property when the spleen has been previously extirpated. The power of conferring immunity possessed by the blood-serum of rabbits which have been vaccinated against infection from pyocyaneus is by no means injured by removal of the spleen. (ii.) Six rabbits were rendered immune against infection from pyocyaneus and after recovery were again tested, and the spleen extirpated. A week after the extirpation 2ccm. of virulent cultures were injected intravenously. All remained healthy, while the control animals died within twenty-four hours. Fourteen days later 2 ccm. of virulent cultures were again intravenously injected, without causing any subsequent injury. As before, the bacteria-killing property was present; the power possessed by the serum for conferring immunity was not in the least upset by extirpation of the spleen.

The following conclusion must be drawn from these investigations, viz.: that extirpation of the spleen, whether before or

after inoculation, exercises no influence on the conference of immunity against infection by the bacillus pyocyaneus. Two further points yet require discussion, *i.e.*, the relation of the spleen to leucocytosis and rise of temperature. Romer and others have shown that intravenous injection of poison of pyocyaneus (like other bacteria-poison) induces always an acute leucocytosis, and it has been lately further proved by the author that the increase of leucocytes principally, and often almost exclusively, concerns the eosinophile cells. Neither the leucocytes nor their relation to the rise of temperature are in the least altered by extirpation of the spleen.

From the author's paper the fact is clear that, as concerning the phenomena of infection by pyocyaneus and the conference of immunity against the bacillus, the spleen exercises no influence, nor is of any importance. (*Centralb. f. Bakt. und Parasit.*, Aug. 1892.)

Podwyssozki and **Sawschenko** give the results of their observations on parasitic forms in cancerous growths. In specimens hardened with Fleming's fluid and stained with saffranin, they describe sporozoa in the cells and between them occurring singly or in masses. They found some filled with sickle-shaped embryonic forms, characteristic of coccidia and sporidia. These sporocystic forms were, however, but rarely met with. Other sickle-shaped forms were abundant. Besides these, there were many globular forms, which they regard as resting stages, and these varied much in size, some being hardly visible, while others were of a fair size. Small parasites also were found in some mitotic cells. These were most often found in the mamma and testis, and the authors do not doubt that these inclusions are parasites. But they cannot decide whether all inclusions are such, and whether the sporozoa all belong to the same species. They suggest that there may be a different form for each variety of carcinoma. Whether they have any etiological importance cannot yet be proved; further experiments and investigations must decide this. (*Centralb. f. Bakt. und Parasit.*, xi., Nos. 16—18.)

A most interesting paper has recently appeared on some parasitic protozoa found in cancerous tumours by **M. A. Ruffer** and **J. H. Walker**. In carcinomatous tumours a careful examination by thin sections shows bodies that are certainly not the result of degenerative processes. They appear to possess all the characteristics of coccidia. The preparations were shown to Metschnikoff, who gave it as his opinion that the bodies were the parasitic protozoa described by Foa, Pfeiffer, and Soudakewitsch. The

authors have carefully investigated several cases of scirrhus of the breast, of columnar epitheliome affecting the alimentary tract (stomach, intestine, colon, rectum, etc.), cancers of the peritoneum and liver, epitheliomata of the tongue and epiglottis, together with the metastatic growths of some of these tumours in the glands and internal organs. At first they failed to find parasites in several instances, but increasing practice enabled them to discover them in nearly every cancer examined. It must not be thought that these parasites are to be found in large numbers throughout the cancerous tumour, and that it is enough to cut a few sections of cancer to make sure of finding some. Section after section may sometimes be examined and not a single one found, until suddenly the investigator's patience is rewarded by finding a nest of these parasites. In one case the authors came close to the edge of the primary tumour before discovering any, and in another case of scirrhus of the breast not one was found in the primary tumour, only in the secondary growths in glands and liver, which were crowded with them. The life of these parasites in a cancerous tumour is a precarious one, the cell often surviving its parasites. The authors attribute their failure to find them in some cases to insufficient examination, and think it a mistake to conclude that, because no parasites are seen, therefore no parasites are present. Their next task was to examine systematically the primary growth and secondary tumour of patients dead from cancer, and to particularly note in what part of each the parasites are most frequently to be found. In most cases the parasites are perfectly spherical. A small nucleus is surrounded by a comparatively large amount of protoplasm. A distinct capsule is also present, which, although not well marked in tissues hardened in alcohol, is plainly visible in specimens fixed in Fleming's solution. The nucleus may be round, oval, or somewhat irregular in shape, generally lies in the centre of the parasite, but not unfrequently is pushed slightly to one side, though never quite against the side. The nucleus may lie perfectly isolated, but more frequently fine delicate rays stretch from it to the periphery. The protoplasm of the parasite may be perfectly homogeneous, or it may have a slightly mottled appearance. Occasionally small granules are scattered through its protoplasm, and often distinct yellow-pigmented bodies are noticed. The parasite sometimes entirely fills the cyst in which it lies, but not always so—it occasionally appears as if floating in the contents of the cyst. The parasites above described are found only in the protoplasm of the cell exclusively. The nucleus does not contain them, and they are not met with in the lymph spaces, except in

the interior of cancer cells. In the majority of cases an infected cell contains one parasite only, but occasionally two or three, and as many as fifteen are found in the same cell. Sometimes several cancer cells fuse together, whilst the walls between the parasitic cysts disappear; then the growth of the parasites increases, till an enormous mass is at last formed. The more degenerated and fibrous the tumour, the smaller is the number of parasites; and in highly-degenerated parts and in the fibrous stroma none at all are met with. The cancer cells containing parasites generally present perfectly normal appearances, or slight marks of degeneration only; in other cases they become more or less vacuolated, and in more advanced stages the nucleus presents characteristic changes—its sharp outline grows dim, and the nucleus fuses more or less with the surrounding protoplasm. In a further stage the nucleus disappears, and the whole cell is converted into a kind of cyst in which the parasite appears to thrive perfectly. It is possible that with the death of the cell the parasite is set free and finds its way into the surrounding lymph stream. The observations made by the authors do not bear out the theory that leucocytes serve as food for cancer cells; they are of opinion that the leucocytes enter the cancer cells, and destroy the parasitic protozoon. Not only did the authors find no traces of degeneration in the leucocytes which had penetrated into cancer cells, but near the growing edge of cancers, as well as in other parts, they often found numerous healthy leucocytes in the interior of cancer cells, and in most cases the cells containing leucocytes were those which were infected with the parasites previously described. The parasite not unfrequently wanders into the very centre of the protozoon, and as a consequence of this penetration the parasite degenerates in its centre and at the periphery. Another very interesting process occurs in cancerous tumours—namely, the destruction of cancerous cells, by the connective tissue forming in the cancerous tumour. At the edge of a growing carcinoma of the liver, for instance, the cancer cells are in some places seen in close contact with the liver cells; in other places, however, the edge is infiltrated by a large number of small round cells, which are either emigrated white corpuscles, or are derived from resting connective tissue elements. The authors, however, do not confirm the latter theory. In cancer, as in the coccidial disease of the rabbit, a wonderful part is played by the cells derived from the mesoblastic layer in defending the organisms against attacking parasites. The struggle of the parasites for life is as easily marked and followed in cancer as in any infectious disease caused by vegetable micro-organisms (*Jour. of Path.*, i. 198.)

Before the annual meeting of the British Medical Association this year **A. Kanthack** read an interesting paper on immunity, phagocytosis, and chemotaxis. Although to impartial observers it would perhaps seem that Petruschky's experiments, performed in 1888, practically decided this question against phagocytosis, Metschnikoff and his followers still contend that the immunity of the frog against anthrax is due to the destructive action of the phagocytes on the bacilli. From original observations, and others repeating and sometimes extending Petruschky's experiments, the author upholds Petruschky's opinion that phagocytes are not responsible for the immunity of frogs against anthrax, but that because the frog and its tissues are resistant against anthrax, therefore the phagocytes are able to take up the bacilli without being destroyed by them.

Kanthack's investigations finally led him to the following conclusions :—

(1) The true pus cells in the frog are eosinophile leucocytes derived from the blood in the first instance, though probably the eosinophile cells proliferate and increase even after they have left the vessels. (2) The great majority of phagocytes, which in the frog do not begin to show themselves until three or four hours after inoculation, are quite distinct from leucocytes, and appear considerably later than the latter. The cells, attracted by so-called chemotaxis, are almost exclusively eosinophile leucocytes. Phagocytosis is a process of repair, and not the *primum movens* of inflammation. The latter commences long before phagocytosis is evident. On inoculating an immune animal with a pathogenic organism it is found that the process remains local, and the first thing observed is inflammation. This, as a rule, goes on to suppuration. The cellular elements of this pus, again, are principally eosinophile leucocytes. It is only after inflammation or suppuration has advanced far enough that phagocytes appear. This the author finds to be the case for anthrax in frogs, for pyocyaneus in the immunised rabbit, for hog cholera, and also for rabbits accustomed to cobra poison. By this it is seen that if an animal is more or less immune against an infective or toxic disease, its tissues react quickly with inflammation, accompanied by well-marked diapedesis and migration of leucocytes; that these leucocytes are in the first instance of the eosinophile kind; and that phagocytosis only appears when these processes are well marked. (3) The inflammation in these immune animals generally leads to the formation of pus. The latter has a great destructive action, being able to dissolve metals and tissues, and to destroy the growth of bacilli in the body as well as in the test-

tube. It has been seen that by chemotaxis non-phagocytic elements (the eosinophile cells) are attracted, and that pus, almost free from phagocytes, consisting almost completely of eosinophile cells, has a great solvent action on extremely insoluble substances, and a destructive action on various organisms. In such local suppurative processes the microbes are in a medium destructive to them, and phagocytes are not necessary to their destruction. It is therefore certain that from local changes no conclusion can be drawn as to the acquisition of immunity, and the question to be answered is—Why, in an immunised animal, does the lesion become localised, while in a natural animal it becomes diffuse? Only when inflammation or suppuration has localised the process does phagocytosis appear; it does not realise the process, but merely removes what is left of the infection carriers. (4) It appears that the eosinophile cells give pus this destructive power, because pure pus consists of nothing but such cells, and by "chemotaxis these cells are attracted." But it must not be thought that this is meant to convey the idea that eosinophile cells are carriers of immunising bodies; the eosinophile leucocytosis makes its appearance only after the animal has been rendered immune. Injecting 1 cc. of pyocyaneus culture intravenously into a normal rabbit kills it, the eosinophile cells decreasing in number; but on injecting the same quantity into an immunised rabbit it survives, and the eosinophile leucocytosis is markedly apparent. It is seen that an immunised animal when injected subcutaneously reacts promptly by inflammation, and the author thinks that this leucocytosis, produced by bacilli or their products, is equivalent to an inflammation of the blood. Chemical irritation causes an increase of the nutritive processes, and is also characterised by a rapid and augmented metabolic activity. The eosinophile cells swell and become richer in granules, are less stable, and have an active proliferation. This form of leucocytosis may therefore, perhaps, be considered an inflammation of the blood. At any rate the changes in the blood are similar to those of other inflamed tissues, except that the blood provides the pus corpuscles itself. The difference, then, between an immunised and a normal animal is that in the former the injection is promptly followed by an inflammation, which is accompanied by a large accumulation of eosinophile cells, the cellular elements of pus; and the latter has a strong solvent or destructive influence on otherwise resistant bodies and certain microbes, which is as important as that of phagocytes, and exerts its influence without the latter. (*Brit. Med. Jour.*, 985.)

G. Vassale, in his experiments on nervous tissue as a culture

medium for microbes, finds that many pathogenic microbes grow excellently on portions of the spinal cord of animals which have been carefully sterilised and put into test-tubes. In this way he studied the S. pyogen., S. erysip., and B. anthracis. The results of inoculating the living brains of guinea-pigs with tubercle bacilli is extremely interesting. All the animals thus treated died, but when examined they showed no local tubercle, very numerous bacilli being found free in the fluids of the ventricles, etc. By these investigations it is seen that tubercle bacilli can multiply well in the nervous system. (*Riv. Sper. di Freniatria*, Fasc. 1, 1892.)

Bombicci, working in Tizzoni's laboratory, has studied the possibilities of the diffusion of influenza by the inhalation of the specific bacilli in a dry state. He finds (1) that the influenza bacillus preserves both its vegetative and pathogenic powers for a considerable time after it has undergone desiccation; (2) that the symptoms of influenza can be induced in rabbits by causing them to inhale the dry bacilli; (3) that the disease produced in rabbits is in some cases limited to a transitory rise of temperature, but in others is characterised by broncho-pneumonia, more or less severe; (4) that one of the means of diffusion of the disease is certainly the air, and that one, if not the only, way by which the virus is introduced into the organism is through the respiratory tract. (*Rif. Med.*, August 18th.)

Immunity.

Hankin and **Westbrook** have investigated the subject of the albumoses and toxine secreted by the bacillus anthracis, and think from them they can explain the reason of Petermann's failure to find any immunising properties in the albumoses which he obtained. If the anthrax cultures be made at a temperature of 37° C., albumoses and peptones are formed; but the former will be found to possess no immunising action. If, however, the cultures be made at room temperature, different albumoses will apparently be produced, corresponding in their properties with those described by Hankin in a former publication. An infinitesimal dose of these substances injected into mice would confer an increased resistance to virulent anthrax. A number—varying between 10 and 50 per cent.—of the animals resisted a single subsequent inoculation. Out of twelve animals which survived the first inoculation eleven succumbed to a second, and the twelfth failed to resist a third inoculation. The protection, therefore, is only temporary. The following are the conclusions drawn from the authors' further investigations:—

(1) The bacillus anthracis forms, as a result of its growth, a

proteolytic ferment which is capable of forming albumoses from proteid material, but possesses no immunising power against anthrax.

(2) The bacillus produces directly another albumose, which can be procured in a state of almost complete purity, if the cultivation be carried on in a medium of pure peptone. This albumose possesses distinct immunising powers.

(3) In ordinary doses the albumose has no toxic effect upon animals which are susceptible to anthrax, but in animals which are comparatively resistant it acts as an energetic toxin.

(4) In young rats the albumose gives rise to no toxic effect, though in adult animals it produces acute poisoning. (*Ann. de l'Institut Pasteur*, September, 1892.)

Valliard and **Rouget** have made the following additions to the observations on tetanus published by one of them last year. The toxine of tetanus is greatly weakened but not absolutely destroyed by prolonged exposure to a temperature of 80° C. Tetanus bacilli and spores contain in themselves large quantities of toxine, which it is very difficult to remove by either heating or prolonged washing on a filter. Rabbits can resist a dose of toxine 2,000 and even 3,000 times greater than that which is fatal to guinea-pigs. Temperatures of 70° or 80° C. do not kill the spores, for when they are injected with a minute trace of lactic acid, they at once become active and intensely virulent. When toxine-free spores are introduced into an animal, they do not germinate, but become speedily engulfed in leucocytes. Two or three days later no spores can be discovered, and probably degeneration is already taking place in some of those enclosed in the cells. This is more marked after a week or so. When the leucocytes are again disabled with lactic acid, on the other hand, they do not congregate as before, and the spores are able to germinate in the somewhat devitalised tissue, and produce their toxine. Tetanus spores thus do sometimes develop under certain abnormal conditions: the existence of hæmorrhage, effusions, bruised muscles, subcutaneous fractures, etc., often enables the spores to get a footing; clean, aseptic, and surgical wounds do not, however, seem to favour the development of the spores. Sterile foreign bodies, impregnated with toxine-free spores, do not seem to aid their growth. Should the wound become septic, then tetanus rapidly appears. A tetanigenous earth will produce tetanus in guinea-pigs. If heated to 85°, it loses this power. This temperature kills all other microbes present excepting the tetanus spores. If these are again associated with ærabic microbes, they once more become active. This association with other microbes

is found to be the same in the human subject; pus taken from the primary injury contains numerous other microbes besides the tetanus bacillus. These other microbes attract leucocytes to the spot; the leucocytes are weakened or destroyed by the metabolic products of the auxiliary bacteria, and thus become fit pabulum for tetanus bacilli. Inoculation of tetanus from one animal to another quickly fails, owing to the ease with which the auxiliary bacilli lose their power of developing in the tissues. After about the third passage these almost disappear, and there is left nearly a pure culture of tetanus bacilli. This accounts for the difficulty with which the disease is spread. So-called idiopathic tetanus is due to a previous infective injury. Spores may be introduced, and, though enveloped by leucocytes, sometimes escape rapid destruction; and any sort of ill-health, such as a bruise or chill, etc., is in favour of the spore. Large wounds are less often followed by tetanus than are small ones, perhaps for the reason that they are more carefully treated with antiseptics. (*Ann. de l'Institut Pasteur*, June.)

Brieger and **Wasserman** publish the results of their further investigations on protective inoculation of animals against Cholera Asiatica. Cholera bacilli were grown upon a watery extract of calf's thymus for 24 hours. The culture medium was then kept at 65° C. for 15 minutes, or at 80° C. for 10 minutes, and subsequently placed in the ice-chest for 24 hours. Intraperitoneal injections of this fluid were made upon guinea-pigs, which thereafter proved immune to cholera bacilli of such virulence as to produce rapid death in the control animals. The minimal dose necessary to protect a guinea-pig of from 300 to 400 g. weight against a fatal dose of cholera culture is 2 cc. (1 cc. injected on two successive days). The authors find that an equal effect is produced when the infected thymus-extract has been merely set aside in an ice-chest for several days without any warming. Precisely similar results were obtained with ordinary bouillon cultures of cholera bacilli which had been kept at 65° C. for 15 minutes. In this case also 2 cc. was the minimal dose necessary to confer protection, which was still complete after the lapse of two months. The authors promise a more detailed communication. (*Deutsch. med. Wochenschr.*, Aug. 4.)

Behring and **Wernicke** have recently made experiments on conferring immunity to, and the experimental cure of diphtheria. The destructive effect of the serum of specifically protected animals on the poison of the diphtheria and tetanus bacilli both in and outside the body was first observed by Behring and Kitasato. This was followed quickly by conclusive researches on

tetanus by Tizzoni and Cattani, who have recently employed the treatment on human subjects, and already met with favourable results. Then came the analogous investigations made by Emmerich on swine erysipelas, and on the bacteria of pneumonia (Emmerich and Fowitzki, Foà and Carboni, G. and F, Klemperer), and from these collective results the conclusion is clear that in all cases the blood and serum of specifically protected animals acts as an antidote against the poison of the particular virus. In the present paper the author gives an account of the further results of these investigations of and experiments on diphtheria. The results are highly remarkable, and the method is far enough advanced to be already employed for the benefit of mankind.

The first thing to be done was to find out a practical method of conferring immunity on the animals subjected to research.

While immunisation was formerly obtained through infection of guinea-pigs with diphtheria bacillus and immediate local treatment with trichloride of iodine, the authors now, with far better results, let the trichloride of iodine act on filtered poisonous cultures outside the body; that is to say, they made weak diphtheria poison, and this is then employed for the immunisation. The dose of diphtheria poison treated with trichloride of iodine was always so large that it elicited a distinct local and general reaction, and it was seen that the strength of the dose must be each time increased in order to obtain with successive doses a reaction of similar degree.

If the reaction is poor, the protective influence is slight or absent altogether; and if the reaction is strong—a circumstance accompanied by progressive emaciation of the animals used for experiment—protection is also usually frustrated. They succeeded, however, in rendering guinea-pigs and sheep fairly secure from infection. With rabbits a different method had to be chosen; either a long series of doses of diphtheria poison into the stomach or, better, subcutaneous inoculation with the lime precipitate thrown down in very poisonous but spore-free cultures. To this precipitate, according to the observations by Roux and Yersin, the poison of diphtheria mechanically adheres. The precipitate must be pulverised and heated for an hour at 77° C. Five millegrams of this diphtheria lime-powder placed under the skin sufficed to cause extensive phlegmonous inflammation all round the seat of inoculation. Later, large quantities of the powder could be gradually made use of.

Closely corresponding to the degree of immunity of the animals is the curative effect to be obtained with its blood and serum.

The authors indicate the degree of power of conferring immunity possessed by the serum, in terms of the smallest dose of serum, which up to the present has been efficient on guinea-pigs. For instance, from an animal, the degree of immunity possessed by which is to be defined, a sample of blood is taken, and with the serum obtained from it a series of guinea-pigs are injected; a day later a certain quantity of diphtheria culture was injected sufficient to kill a full-grown guinea-pig in three or four days' time. The way in which the serum confers immunity on the animals so treated consists most certainly not merely in inducing the particular change of constitution evinced, but in the animal receiving, in virtue of the serum injected, certain of the capabilities and properties of those animals from which the serum is obtained. For the attainment of a curative effect larger quantities of serum are required than for conferring immunity. The power, moreover, lies in the serum; the entire blood displays little power; and the dried and afterwards with salt water extracted blood corpuscles produce but meagre results.

As to the chemical nature of the curative bodies in the serum, the authors admit they do not know anything precise. (*Zeitschr. f. Hygiene und Infectionskrankheiten*, xii. 811.)

N. Pane, writing on the action of the serum of rabbits', dogs', and pigeons' blood on anthrax bacilli, holds that the rabbit is less susceptible to anthrax than is supposed. In opposition to Lubarsch, Pane holds that of tissues possessing the power of killing bacteria, especially the bacillus of splenic fever, the subcutaneous possess it in higher degree than does the circulating blood. A ccm. of serum from the blood of a freshly-killed rabbit destroys from 167 to about 8,000 bacilli; the power of killing bacteria is therefore significantly higher outside than inside the body. Guinea-pigs which had been inoculated with from 30 to 150 bacilli, and into which 1 ccm. of serum of blood from a rabbit had previously been injected, died of typical anthrax, with very little delay of the date of death. They, however, remained alive if they were merely inoculated with from 1 to 10 bacilli of anthrax and with 1 ccm. of blood-serum, while on the other hand four out of five control animals died. Hence the blood-serum of rabbits, if injected into guinea-pigs, is able to render them immune from anthrax bacilli. The blood-serum of dogs exercises no injurious effect upon anthrax bacilli if they are introduced in the proportions of less than 100 bacilli in 1 ccm. of serum; indeed, they thrive in it well. The attempt to make guinea-pigs insusceptible to anthrax by means of injection of dog's serum was not successful. Pigeon's serum

displays the same want of power to destroy anthrax bacilli. Heating up to 55° C. for half an hour does not destroy the bacteria-killing property of rabbit serum; 1 per cent. sodium carbonate solution kills anthrax bacilli in ten minutes, 2 per cent. sodium bicarbonate solution kills them in one hour. Perhaps the alkalinity of the rabbit serum has something to do with its power of killing bacteria. (*Rivista. Clin, e Terap.*, xiii. 481.)

Sidney Martin has this year achieved a further remarkable success in the chemistry of the specific fevers. He has isolated from the bodies of persons dead of diphtheria poisonous substances, obtaining them more abundantly from the spleen than from other organs. The poisons are in nature albumoses, that is to say of proteid, and soluble in water, while incoagulable by heat. With the albumoses is associated an organic acid. The symptoms produced by these poisons are chiefly local inflammation and irregularity of temperature, accompanied by loss of weight and followed by disseminated paralyses, especially of the hind limbs. Martin has also found that the bacillus diphtheriæ forms from proteids products of the same chemical nature as those found in the bodies of patients dead of diphtheria—namely, albumoses and an organic acid. The albumoses formed by the bacillus diphtheriæ in artificial cultivation have in single and multiple doses the same physiological action as those found in cases of diphtheria in man. The progressive paresis of the muscles which they produce is dependent on a degeneration of the peripheral nerves. The bacillus diphtheriæ is therefore the primary infective agent in diphtheria. From Roux and Yersin's work it is obvious that a much more virulent poison than any existing inside the body of patients suffering from diptheria exists in the diphtheritic membrane at the surface of the body. The chemical pathology of diphtheria is similar in a sense to a digestive process, and can be termed diptheria digestion.

DIPHTHERIA DIGESTION.

Primary Infective Agent.	*Secondary Infective Agent.*	*Digestive Products.*
Bacillus diphtheriæ.	Diphtheria ferment (Roux and Yersin).	Hetero-albumose Proto-albumose Deutero-albumose Organic acid.

It is evident that the primary infective agent in diphtheria is the bacillus diphtheriæ; that this liberates in the membrane a ferment which, when absorbed, digests the proteids of the body, forming albumoses and an organic acid. These digested products are the agents in producing death, in causing fever, the depression and the paralysis which follow diphtheria. It is clear, from the

cases of diphtheria which have been described, that the diphtheria products found in the body do not all come direct from the membrane. In case 1, for example, only small flecks of membrane were found in the larynx, and yet in the body a large quantity of the diphtheria products was discovered. The large amount of albumoses and organic acid found in the spleen also shows that something more than absorption from the membrane is going on. There is no reason to suppose that these products merely accumulate in the spleen, and their specific physiological action shows that they are foreign to the organism. It is more probable that the ferment absorbed from the membrane digests the more or less stagnating proteids in that organ; and we know, indeed, that the spleen contains a proportionately larger quantity than the blood of bodies formed from proteids, such as uric acid, xanthin, etc. (*Goulstonian Lectures*, Royal College of Physicians, March.)

BIOLOGY (BOTANICAL).

SYSTEMATIC AND GEOGRAPHICAL BOTANY.

By W. BOTTING HEMSLEY, F.R.S., A.L.S.

Nomenclature.

This subject is placed first, because there has been unusual activity in this direction. **O. Kuntze's** "Revisio Genera Plantarum Vascularium omnium atque Cellularum multarum secundum Leges Nomenclaturæ Internationales," of which some particulars were given in this publication last year, has caused considerable commotion in the botanical world, and has given rise to no inconsiderable amount of writing on this difficult subject—for difficult it is, whatever standpoint is taken; and it has also given rise to action in the matter of names. Briefly stated, the question involves the earliest authority for generic and specific appellations, and especially the authority for the earliest combination of genus and species under what is generally accepted as the right genus. The extremists, on the one hand, hold for the adoption of the earliest generic and specific names that can be traced to a plant, no matter how obscure or how remote, and the authority for such names, the author who first used them, either separately or in combination, whether before or after Linnæus promulgated his binominal system of nomenclature. That is to say, any accidental or actual reduction of the old diagnostic phrase to two words, deemed generic and specific, in any earlier author's works, is considered sufficient to warrant the use of that particular author's name as the authority for such combination under the binominal system, provided, of course, any such combination is still in use—and there are many. But the matter of "authority" is of little importance beside the question whether a name that has been in general use for a hundred years or more should be replaced by a forgotten one applied by an earlier author, whether a month earlier or fifty years earlier. On the other hand, the conservatives, if they may be so called, would continue to use names that have long been current, regardless of the law of priority, though they would observe priority in all recent work. Of course there is much to be said for and against both strict

priority and convenience or expedience in the matter of nomenclature. Yet to the philosophic mind it is of the very smallest importance what name you give an object, provided it is generally understood what is meant. If a genus or a species were an exact quantity, concerning which there could be no dispute, then we might and could insist on strict rules in nomenclature. As it is, however, much depends upon the course taken by the larger botanical establishments. Fortunately, the current of opinion seems to be strongly in favour of taking the first edition of Linnæus's "Species Plantarum" (1753) as the point of departure. Further, the German botanists, almost unanimously, and supported by many of the most influential botanists of other countries, propose retaining (see *Berichte der deutschen botanischen Gesellschaft*, x. 332) familiar current generic names, though earlier generic names have been applied to some of the species of the genera in question. This course is likely to meet with favour, except with those who regard the disinterring of obscure names as "science" and "erudition." But this is not the place to discuss the matter, and we have only space to give references to some of the more important utterances on this point.

The Director of Kew Gardens, Mr. Thiselton-Dyer (*Nature*, xlvii. 53), most emphatically subordinates priority to convenience; and in the same place a letter is reprinted setting forth the views of the late Dr. A. Gray and Dr. S. Watson, of Harvard. On the other side we may cite the editors of the *Bulletin of the Torrey Botanical Club*, New York (N. L. Britton), of the *Journal of Botany*, London (J. Britten), and of *Pittonia*, San Francisco (E. L. Greene), in their respective publications, though they are not in accord on all points.

It may also be mentioned that an attempt has been made in the recently issued "Supplement to English Botany" to carry out the law of priority, with the result that a young botanist appears as sponsor for the names of a number of familiar British plants. One thing to be said in favour of the conservatives is that they continue to use names commonly found in books.

Descriptive.

Many papers summarised here are a combination of descriptive and geographical work, but the predominating element has influenced the classification.

The British Flora.

Two parts of the promised Supplement to "English Botany" have appeared, "compiled and illustrated" by **N. E. Brown.**

They run from the Ranunculaceæ to the middle of the Rosaceæ. The plants figured are: Ranunculus flabellatus, Desf., formerly found near St. Aubin, Jersey; Brassica Napus, L., "to be substituted for plate 88 in vol. i.;" Arabis alpina, Linn., from the Isle of Skye; Polygala amara, Linn., "not of Jacquin;" Claytonia sibirica, Linn. (Portulaceæ), naturalised in several places in the North of England and in Scotland; Lavatera cretica, Linn., a plant resembling Malva sylvestris, colonised in two or three localities in the West of England; and Potentilla norvegica, Linn., which has established itself in several counties. Figures of these introduced plants are perhaps even more useful from a botanical standpoint than figures of our very common plants; yet it would be difficult to determine where to stop. The text of these two parts will be welcome to persons interested in the history of names, as much care has evidently been bestowed on working out generic priorities.

Part iii. has since appeared, completing the first volume of the Supplement, and carrying the work on to the Dipsaceæ. The plants figured are:—Pyrus rotundifolia, P. pinnatifida, P. semipinnata, P. cordata, and Selinum carvifolia.

A new Ranunculus—R. petiolaris—is figured and described (*Journ. Bot.*, 1892, p. 289, t. 328) by **E. S. Marshall.** It has been found in abundance on the gravelly margins of small Highland lakes in Argyle, Skye, and Sutherlandshire, and it grows by preference in water two or three inches deep, sometimes associated with Subularia aquatica. It is very closely allied to R. flammula (Linn.), from which it differs in the radical leaves being reduced to short, subulate, recurved petioles, and the petals are very much narrowed at the base. So far these characters are constant under cultivation.

A supposed hybrid orchid, between Habenaria viridis and Orchis maculata, is figured and described (*Ann. Bot.*, vi. 325, t. 18) by **R. A. Rolfe.** It was found by Mr. C. H. Spencer Perceval near Longwitton, in Northumberland. Natural hybrid orchids are not so very rare on the Continent, but very few are recorded as British.

A key to British Rubi, or rather an "essay" at one, prepared by **W. Moyle Rogers** (*Journ. Bot.*, 1892), will be a great help to students of this fascinating genus.

A new British Rubus—R. Durotrigum—is described (*Journ. Bot.*, 1892, p. 15) by **R. P. Murray.** It was found plentifully in bushy ground, adjoining Charlton Down, Dorset; and the specific name "refers to the Durotriges, a people who formerly occupied this part of the country."

W. A. Clarke has commenced publishing (*Journ. Bot.*, 1892) a most useful and interesting compilation, entitled "First Records of British Flowering Plants." Apart from its interest it opens up a view into the literature of British botany. The starting-point is Turner's *Libellus de re Herbaria Novus*, 1538.

G. Massee has published the first volume of a new "British Fungus Flora;" and it is estimated that two more volumes will be sufficient for the description of the whole of the British Fungi. It is now twenty-one years since the last complete British Mycological Flora was published, and during that period the number of species has been nearly doubled. The number of species described in Cooke's "Handbook" is 2,810, whereas, Mr. Massee says, "the species now number 4,895, and are distributed as follows:—Basidiomycetes, 1,980; Ascomycetes, 1,275; Sphæropsideæ, 685; Hyphomycetes, 580; Uredineæ and Ustilagineæ, 230; Phycomycetes, 145." The present volume treats of a portion of the Basidiomycetes, or what may be termed macroscopic fungi, including the more familiar genera, Lycoperdon, Boletus, Polyporus, and the Agaricineæ. Mr. Massee has taken the various works of the late Professor E. Fries as the basis of the descriptions, but he has departed from him in one important particular. The genus Agaricus, as understood by Fries, consisted of hundreds of species, which he grouped in sections. In the present work these sections are raised to generic rank, which simplifies the nomenclature. Thus Agaricus (Hypholoma) capnoides becomes Hypholoma capnoides. In this way Agaricus itself is restricted to a dozen species. A good plan has been adopted in this work: instead of adapting and more or less modifying the descriptions of other authors, they are given word for word, and the source cited in brackets at the end; hence it is not difficult to distinguish the original from the borrowed; and the compiler takes no responsibility for the possible errors of his predecessors. So many of the fungi are exceedingly rare that this course is almost a necessity. Details are given of the most useful and interesting species.

The Asiatic Flora.

Flora of British India.—**Sir Joseph Hooker's** great work has reached the eighteenth part—that is, the second part of the sixth volume. This contains the petaloid monocots after orchids, and about half the palms, of which 34 genera are represented in India.

The third volume of the *Annals of the Royal Botanic Garden*, Calcutta, was actually completed in 1891, but only portions of it reached this country. **D. Prain's** monograph of the Indian species

of Pedicularis was noticed last year. Since then we have seen the 37 excellent plates illustrating the species. Dr. Prain also contributes an illustrated monograph of Gomphostemma, a small genus of the Labiatæ. The rest of this huge volume is the work of Dr. G. King, and comprises monographs of the Magnoliaceæ and the species of Myristica (nutmegs) of British India. As in previous monographs, the whole of the species are figured. The Magnoliaceæ are illustrated by 37 plates, including a small number of new species. Myristica numbers 86 species, of which a large number are here figured and described for the first time. With one exception, M. canarioides, these trees are diœcious, and it is often exceedingly difficult to identify from herbarium materials the males and females of the same species. The exceptional species mentioned bears the male and female flowers on the same tree. The synonymy of the common nutmeg of commerce is Myristica fragrans, Houtt, syn. M. moschata, Thunb., and M. officinalis, Linn. f.

The fourth part of G. King's work, *Materials for a Flora of the Malay Peninsula*, is devoted to the Anonaceæ, and affords further proof of the immense wealth of the arboreous element of the Malayan flora. Nearly 200 species belonging to 25 genera are described, and out of these 75 species are new. Very few and slight changes have been made in the limitation of the genera, which is certainly remarkable with this great accession of species.

Recherchés sur les Dipterocarpacées is the title of an essay F. Heim has published on the anatomy, organography, and classification of this important natural order of trees, in the form of an introduction to a general monograph of the order, which he contemplates writing. Recent and older previously unelaborated collections from the Malayan region contained such a vast quantity of new material that it is not surprising to find that he has established a number of new genera, though it is probable that he will reduce some of them himself when he comes to deal with all the species of the order. He proposes about a dozen new genera—a third of them tentatively, it should be explained. Some of these genera, on the other hand, are remarkably distinct. With regard to the limitation of the order, Dr. Heim would exclude Lophira and Monotes, commonly referred here—at least the latter. The former has been regarded by many botanists as the type of a natural order itself. The latter Dr. Heim would place near Grewia in Tiliaceæ. Anatomical characters greatly influence the author in some of the changes he has made. Ancistrodadus is also treated as the type of a natural order, and most botanists will agree with this view. This essay also includes

excellent plates of the genera Leitneria, Chapman, and Mastixia, Blume.

Otto Stapf has monographed the Sonerileæ of Asia (*Ann. Bot.*, vi. 291, with a map showing their distribution), and has given his views of their affinities. He founds two new genera—namely, Fordiophyton and Gymnagathis—both of which had been referred, with some reservations, by Prof. D. Oliver, to Sonerila itself. Both genera differ from Sonerila in having tetramerous stamens and two whorls of inappendiculate stamens; and the former from the latter in having large membranous deciduous calyx-teeth.

The Vegetation of the Coco group is the title of a very elaborate paper (*Journ. Asiatic Soc. Bengal*, vol. lx., part 2) by **D. Prain**, dealing with the character and distribution of the plants forming the vegetation of these islands. The Cocos are a small group of three islands—Table Island, Great Coco, and Little Coco—lying about 30 to 45 miles north of Landfall Island, the most northerly of the Andaman group in the Bay of Bengal. Dr. Prain's analysis of the flora is the outcome of two short visits in 1889 and 1890. He gives very full details of the local conditions and of the composition of the vegetation in various localities in the three islands, also of the means by which he supposes many of the plants reached the islands. He concludes that 80 per cent. of the flora may have been introduced—namely, 9 per cent. by human agency, 28 per cent. by birds, 17 per cent. by winds, and 28 per cent. by the sea. The total number of species collected in the group was 358. Xylaria clavarioides is the only new species described. (*See* also below, p. 472.)

The same author in the same journal (pp. 156—175) gives an account of a visit to Little Andaman and the Nicobars, with a catalogue of the plants collected, and notes on those of special interest. No new species were collected.

L. Pierre's huge "Flore Forestière de la Cochinchine" has reached the seventeenth part and the 272nd plate. As heretofore, the plates are full of detail, and one is filled with wonder at the vast and elaborate scale of the work. This part contains the end of the Dipterocarpeæ, the Stryaceæ, Simarubeæ, Olacineæ, and Malpighiaceæ. Many curious new plants are figured, and Dr. Pierre enters into minute details of their affinities. The question of priority in nomenclature of genera often comes under discussion.

New Chinese and Japanese plants.

A. Franchet has published many more novelties, including a monograph of the Lilies (*Journ. de Botanique*, Sept., 1892), where

he describes about a dozen new ones, some of them highly ornamental. He has also contributed an account (*Bull. Soc. Bot. France*, xxxix. 126) of the species of Leontopodium (Edelweiss), or Gnaphalium § Leontopodium, from which we learn that eight species out of ten occur in China. **W. B. Hemsley** has a paper (*Journ. Linn. Soc.*, xxix. 298, pls. 29—33) on a collection of plants made by Mr. A. E. Pratt in Western China, with descriptions of new species from various collections. The new species belong largely to the genera Rubus, Saussurea, Primula, and Lysimachia; and there are five new orchids described by **R. A. Rolfe**; but the most interesting of all is a distinct new type of Oxyria, of caulescent habit. The only previous known species, O. digyna, is widely spread all round the northern hemisphere in cold latitudes and altitudes, though it has not hitherto been found either in China or Japan. It may be added, from the writer's own knowledge, there are yet hundreds of Chinese plants in the herbaria of Kew and Paris awaiting description.

The *Japanese Botanical Magazine* contains figures of several new Japanese plants, among them Saxifraga Watanabei, a giant species with large palmate leaves; Senecio Makineanus, Calanthe kirishimensis, and Polygonatum amabile.

A. Batalin has taken up the work of the late Mr. Maximowicz, in so far that he has commenced the publication of fasciculi of new Asiatic plants, chiefly Chinese, some of them collected by Dr. A. Henry. Two fasciculi have appeared (*Acta Horti Petropolitani*, vols. xi. and xii), and they contain descriptions of twenty-seven new plants, mostly of an ornamental character, belonging to such genera as Prunus, Ribes, Lonicera, Rhododendron, Primula, and Incarvillea. Corallodiscus is a proposed new genus of the Cyrtandreæ, most nearly related to Haberlea. Judging from the dimensions given, it must be quite a miniature member of this order, which is represented in China by so many charming little plants.

Australasian and Polynesian Flora.

The genus Stylidium.—Under the title "Iconography of Candolleaceous Plants," **Sir Ferdinand von Mueller** has issued, under the auspices of the Victorian Government, the first decade of illustrations of this interesting, large, and almost wholly Australian genus. Nearly a hundred species of these often elegant little herbaceous plants inhabit Australia, and they present not only great diversity in the foliage and inflorescence, but also very marked and diversified characters in the seed-vessel.

Ferns of Queensland.—**F. M. Bailey** has issued "lithograms" of all the known Ferns of Queensland. The book is an octavo,

and the figures not of the clearest; but they will, nevertheless, be of great service to the student.

Flora of Melville Island.—This island is situated about forty miles to the north of Port Darwin, North-West Australia. A Government exploring party visited it in 1887, and **Mr. M. Holtze** has recently given an account of the vegetation (*Trans. Roy. Soc. South Australia*, xv. 114), together with a list of all the plants observed. The vegetation is much more strictly Australian in character than it is on the eastern coast, where the tropical element is more prominent. The timber-trees consist largely of Eucalyptus, Grevillea, Acacia, Bombax, and Metrosideros; and Leguminosæ, Myrtaceæ, and Proteaceæ are specially numerous in species. Mr. Holtze states that Lycopodium cernuum was the only plant met with that he had not previously collected on the mainland. A curiosity was discovered in the form of a palm, Livistona humilis, with four distinct branches.

E. Drake del Castillo has brought to a close his "Illustrationes Floræ Insularum Maris Pacifici" with an enumeration of all the plants known to him from the Fiji, Tonga, Samoa, Society, Marquesas, and Hawaian Islands. This work is a quarto of 458 pages, with 50 beautifully executed plates by D'Apreval. It is doubtless, so far as the French islands are concerned, very complete, but it does not include nearly all that is known from the Fijis, for example. Nevertheless, it is a valuable contribution to botanical literature. Thirteen out of the 50 plates represent new species of characteristic Polynesian genera.

New Genera of Sapotaceæ from Polynesia.—**W. B. Hemsley** has published (*Annals of Botany*, 203, tt. 11–14) two proposed new genera of Sapotaceæ—Chelonespermum and Cassidispermum. They are remarkable for the unusual shape of their seeds, upon which the genera are really founded. In Chelonespermum only one out of two ovules develops into a seed, which is enclosed in a fleshy egg-shaped fruit about three inches long. The seed is erect, and presents two very different surfaces, which may be termed dorsal and ventral. The dorsal surface is smooth, shining, and brown in colour, resembling in miniature the carapace of a turtle or tortoise with an overlapping margin. The ventral surface, the side of the attachment of the seed to the placenta, is quite different in texture, and is more or less tuberculate, spinose, or lamellate. These plants are natives, so far as known, of Polynesia, two species having been collected in the Solomon Islands and one in Fiji. In the Solomon Islands the natives call the seeds "turtle seeds," hence the generic name selected. Cassidispermum has seeds similar in character but

spheroidal in shape, and very different in the shape and position of the embryo. [*See* also *Antarctic Islands*, p. 461.]

The African Flora.

Contributions to the Flora of Tropical and South Africa.—Under the title "Beiträge zur Flora von Africa" various botanists have worked out (*Engler's Jahrbücher*, xv.) the new material of a number of natural orders—among them, the Burseraceæ, Anacardiaceæ, Tiliaceæ, Sterculiaceæ, Monocotyledones Petaloideæ, Turneraceæ, and Aroideæ. Numerous new species are described, and the following new genera:—Hydrophrynium (Scitamineæ) and Alocasiophyllum and Pseudohydrosma (Aroideæ). Phyllodes is a revived name for Phrynium, and Donax for Calathea. It seems a pity to make such cumbersome specific names as Meyeri-Johannis. In the same publication Dr. K. Schumann has an illustrated paper on the caoutchouc plants of Africa, with descriptions of some new species.

Zum Rudolph-See und Stephanie-See, by Ludwig Ritter von Höhnel. In this book **Dr. G. Schweinfurth** gives a list of the plants collected, together with descriptions of many new species, and one new genus, Höhnelia, of the Compositæ, allied to Sparganophorum.

Flora of Bourbon Island.—The first part of the long-expected "Flore de l'Ile de la Réunion" (by **E. J. de Cordemoy**) has appeared. It contains the vascular cryptogams. The ferns number 197 species, of which 23 are, on the authority of the author, peculiar to the island. Some of these, we believe, are described for the first time, though this is not stated. Ten species of Lycopodium and eight of Selaginella, with Psilotum triquetrum, make up this part. The genera are figured.

The Ferns of South Africa.—A fully illustrated and carefully compiled handbook, by **T. R. Sim**, has just appeared.

The American Flora.

"*The Silva of North America.*"—The beautifully illustrated work bearing the above title will consist of about twelve quarto volumes, of which four have already appeared. It will contain uncoloured figures, descriptions, history, synonymy, distribution, uses, etc., of all the trees and large shrubs of the whole of North America, exclusive of Mexico. Evidently neither time nor expense has been spared in the production. The drawings by C. E. Faxon are admirable, and the engraving by the brothers Picart, under the superintendence of the veteran botanical artist Riocreux, is deserving of all praise; whilst the exhaustive though concise text, by Professor Sargent, is a model of accuracy and a mine of

information. The arrangement is systematic, the sequence of Bentham and Hooker's Genera Plantarum being adopted, and the fourth volume brings the work down to the end of the Rosaceæ. As the greater part of the North American trees are hardy in the United Kingdom, and nearly all of them in the western parts, Professor Sargent's Silva will be most welcome to persons who are interested in them, and who can afford such a luxury; for a luxury it is, the price for the twelve volumes being sixty pounds. Turning to plate 158, representing Prunus virginiana, Linn., a tree closely allied to the Bird Cherry of Europe, we find that it has received no fewer than twenty-four different names under the generic appellations of Prunus, Padus, and Cerasus; which means that about eight forms have been given specific rank by different botanists. References are given to the books in which these varieties are described, as well as to the sources of all other information. We learn that this is the most widely-distributed North American tree, ranging from within the Arctic circle (62° lat.) to Northern Mexico, and from the Atlantic to the Pacific Oceans. The question of priority in nomenclature has induced Professor Sargent to make some changes that will hardly meet with general approval, and, even if accepted, will not be current for generations, outside of botanical books and circles. Thus the first tree figured, our favourite Magnolia grandiflora, which has "deliciously fragrant" flowers, becomes Magnolia fœtida, because Linnæus gave it that name as a variety under another species, a few years before he understood that it was a distinct species, and himself gave it the name grandiflora.

Grasses of the Pacific Slope.—The thirteenth Bulletin of the United States Department of Agriculture, Division of Botany, consists of the first part of an illustrated and descriptive monograph of the grasses of California, Oregon, Washington, and the North-Western Coast, including Alaska. Practically, therefore, the work will contain nearly all the grasses of Western Canada and British Columbia. Dr. George Vasey is the author, and one more part will conclude the volume, constituting the second volume of "Illustrations of North American Grasses." The present part contains fifty excellently lithographed plates representing one, or sometimes two, species; and the letterpress is restricted to the description and distribution of the species.

The Flora of Western Texas.—The United States Department of Agriculture has issued the second part of J. M. Coulter's "Manual" of the botany of this interesting region. It contains the Gamopetalæ—the Polypetalæ formed the first part, which appeared in 1891. The whole is written in English, and the

arrangement of the matter is very similar to the late Dr. A. Gray's "Synoptical Flora of North America," to which the author states he is greatly indebted. Nearly half of this part is taken up by the Compositæ, which is the predominating natural order in Texas and Mexico. About 450 species of this order, belonging to 127 genera, are enumerated. There are lithographic figures of a few novelties and little-known plants.

Flora of Carmen Island.—"This island is situated in the lower part of the Gulf of California, two-thirds of the way down the lower California coast, almost in sight of land. It is made up mostly of low hills, which in the north are only about 200 feet high, but in the south rise from 800 to 1,000 feet. The surface is rocky, with very poor or no soil. There are no trees, and a few shrubs, sometimes fifteen feet high, give the prominent floral features to the island." The foregoing is an extract from an account by **J. N. Rose** (*Contributions from the United States National Herbarium*, i., n. 5) of a collection of plants made by D. E. Palmer. It is assumed that the island has been almost exhaustively botanised, and the total number of species collected is 68, belonging to no fewer than 60 genera. Seven of these species have not hitherto been found elsewhere; 49 are known to be common to the peninsula and island, and 29 are also common to Mexico. Out of the total, 37 belong to four natural orders—namely, Compositæ 12, Gramineæ 12, Leguminosæ 7, and Euphorbiaceæ 6.

Cocos Island and the Galapagos.—In the same publication the same botanist gives lists of plants from these islands; but they contain nothing of particular interest, though the flora of Cocos was previously almost unknown, and a considerable varied vegetation is known to exist. When H.M.S. *Sulphur* touched at this island many years ago, about a dozen plants were brought away, ten of which were described as new. However, the plants catalogued by Mr. Rose were collected during a short trip ashore by an officer of U.S.S. *Albatross*, and by no means represent the flora.

Mexican New Plants.—**B. L. Robinson** describes (*Proc. Am. Acad.*, xxvii.) a large number of novelties collected by C. G. Pringle in 1890-1. They consist largely of Compositæ, which seem to be almost inexhaustible in Mexico. Two new genera are proposed: Coulterophytum (Umbelliferæ), resembling Arracacia, but referred to the tribe Selineæ; and Geissolepis (Compositæ), placed near Blepharipappus in the subtribe Galinsogeæ.

Flora of the West Indies.—**J. Urban** has commenced a series of contributions (*Engler's Botanische Jahrbücher*, xv.) on new or

imperfectly-known plants of this region; and he has issued separate copies of the first part—unfortunately, paged separately, though the original pages are given as well. The work is of a highly critical character; and the nomenclature is according to the strict rule of priority, so that such a familiar name as Myroxylon takes the place of the almost equally familiar Xylosma.

Flora Brasiliensis.—Parts 111 and 112 appeared during the past year, and this great work is rapidly approaching completion. The only important large natural order not worked out is the Orchideæ, on which Professor Cogniaux has been engaged for some months, and the first portion may soon be expected.

Geographical.

Biologic Regions and Tabulation Areas.—**C. B. Clarke** submits a plan (*Phil. Trans.* clxxxiii.) for dividing the world into tabulation areas for the working out of the geographical distribution of plants and animals. The maximum number he proposes is 23. We have only space to draw attention to this plan, "which coincides in the main with the zoogeographic map of Wallace."

The River Thames as an Agent in Plant Dispersal.—**H. B. Guppy** gives the result (*Journ. Linn. Soc.*, xxix. 333) of a long series of observations on the seeds, fruits, bulblets, and other living parts of plants found floating in the Thames. He has specially directed his attention to their floating capabilities, duration of vitality in water, in ice, and under other conditions. He found that the germinating power of seeds enclosed in ice for three weeks was not in the least impaired. He has also some interesting notes on the hybernating of various seeds, etc., that sink to the bottom of the water after a certain period.

The Flora of Russian Lapland.—With the exception of some of the coast districts, little was known previous to 1887 of the natural history of the immense Kola peninsula, lying between 66° and 70° N. lat. In the year named, an expedition visited that country for the purpose of investigating its physical and natural history, which has resulted in the publication of a number of highly interesting reports in *Fennia*, and in the *Acta Societatis pro Fauna et Flora Fennica.* Foremost among these is "Ein Beitrag zur Kentniss der regionalen Gliederung an der polaren Waldgrenze," by **A. O. Kihlman.** The aspects of arboreous and shrubby vegetation on its northern limits are admirably illustrated by a series of photolithographs, accompanied by upwards of 250 pages of explanatory letterpress. Particulars of size, age, and condition are given very fully, especially of the characteristic

Pinus sylvestris, Picea excelsa, and Betula odorata. These and other trees diminish in size northward until they are reduced to dwarf shrubs, which are covered by snow in winter, and thus preserved from actual extinction. It may be added, too, that the narrative of the journey and the report on the geology are also intensely interesting.

Immigration of the Spruce Fir in Scandinavia.—This is the subject of a lengthy essay (*Engler's Jahrbücher*, xv. 1) by **Rutger Sernander**, who examines and discusses a mass of facts with great ability, and finally comes to the conclusion that further evidence is required to solve the problem of the present northern distribution of this tree. Such evidence, he expects, will be found in the great Russian peat beds.

Mountain plants of German New Guinea.—**O. Warburg** has an interesting paper on the "Bergpflanzen aus Kaiser Wilhelmsland" (*Engler's Jahrbücher*, xvi. 1), including descriptions of several novelties, and a figure of Hellwigia pulchra, an ornamental new genus of the Scitamineæ. Zoelleria is a remarkable new genus of Boraginaceæ characterised by having ten nutlets instead of only four. This paper is an account of a small collection made by Dr. Hellwig during a four days' return journey from a dashing expedition to the Finisterre Mountains. The greatest altitude reached was about 6,000 feet above sea-level. Out of a total of 53 species of flowering plants 20 were new, and six others peculiar to the island, whilst probably 6 of those of which the material was insufficent for determination will also prove to be new, making a total of 32 endemic species in a collection of 53 species. Among the new species were 7 orchids and 5 rhododendrons. The most striking feature of the collection was the total absence of essentially Australian types. Only five of the species are common to Australia, and they are all widely-spread plants. For the rest the new species belong to genera characteristic of the Malayan flora rather than the Australian.

To J. P. Thomson's "British New Guinea" **Sir F. von Mueller** contributes a brief, though interesting summary of what is known of the vegetation of this comparatively new addition to the British Empire.

Botany of the Antarctic Islands.—Under this title **T. Kirk** has consolidated (*Report of the third meeting of the Australasian Association for the Advancement of Science*) all that was known of the composition of the vegetation of the smaller islands of the New Zealand region—namely, the Snares, Auckland, Campbell Antipodes, and Macquarie Islands. He himself has visited most of the islands, or the principal ones of the groups;

and he was the first to botanise the Snares and Antipodes Islands; but the principal islands were so well explored botanically by Sir Joseph Hooker and Dr. Lyall, in connection with Sir James Ross's antarctic expedition in 1840, that little was left to discover. Nevertheless, Mr. Kirk collected a good many novelties, considering the small number of species constituting the vegetation of these isolated specks of land. His principal discoveries were alluded to in the last issue of this "Year-Book." The vegetation of these remote islands and groups of islands is of the most absorbing interest, and never fails to excite our wonder and admiration. Especially remarkable is the endemic flora of the Auckland Islands, distant some 200 miles south of New Zealand. The entire group is thirty-three miles in length from north to south, and about fifteen miles in breadth at the southern extremity; and the highest hills are upwards of 2,000 feet above the sea-level. Metrosideros lucida, Dracophyllum longifolium, Coprosma fœtidissima, and Myrsine divaricata are the principal trees, the largest of which, the first-named, rarely attains a height of 40 feet. But the showy and robust herbaceous plants, found here and in Campbell Island, and nowhere else in the world, are the glory of these islands. Prominent among them are Ligusticum latifolium, a noble umbellifer with large umbels of pink or red flowers, and Pleurophyllum speciosum, a member of the compositæ, with "flat rosettes of leaves, 3 to 4 feet in diameter, from the centre of which rise several stems 1½ to 2½ feet high, carrying numerous pedunculate, rayed flower-heads 1½ in. in diameter, with whitish rays and deep purple centres." "The leaves are grooved longitudinally and lie perfectly flat, presenting a unique effect, and, as the plant often covers acres, it approaches the magnificent." P. criniferum is of a very different habit, with erect leaves 3 feet in length and flower-scapes 3 to 4 feet high, "the flower-heads resembling large velvet-covered buttons of a deep brown colour, contrasting well with the snow-white tomentum of the scape and peduncles." Chrysobactron Rossii is a fine liliaceous plant, having scapes crowded with bright orange-coloured flowers. Myosotis capitata, Gentiana concinna, and G. cerina are very ornamental plants of much smaller dimensions.

The mountain flora of tropical Africa.—"Ueber die Hochgebirgsflora des tropischen Afrika" is the title of an elaborate compilation on this subject by Dr. A. Engler. It does not add much to previous knowledge—or, rather, it does not contain many new facts—but as a consolidation of all that is known, it is most welcome. It is a quarto of upwards of 450 pages,

and contains a catalogue of all the vascular plants hitherto collected, with their geographical distribution, besides descriptions of a considerable number of new species. About 100 pages are devoted to an analysis of the vegetation of the various mountains and a discussion of the relationships of the floras to each other and to the floras of other parts of the world. Unfortunately, there is no general summary and conclusions, so that it is difficult to extract the more interesting particulars. The author states that the principal object of his investigations was to ascertain the relationships of the highland flora of tropical Africa to those of the neighbouring countries. The absence from all the mountains of tropical Africa of many orders and genera found on most of the mountains of Europe, Asia, and North America, and partly also on the Atlas chain and the mountains of the Indian Archipelago and Central and South America, is one of the most important facts elucidated in phytogeography. Equally interesting is the absence of several orders and genera which constitute the principal elements of the south-western Cape floras. To the first category belong the Abietineæ, Fagaceæ, Betulaceæ, Rhododendreæ, Vaccinieæ, Pyrolaceæ, Aceraceæ, Caprifoliaceæ, Cornaceæ, Spiræeæ, Pomaceæ, Amygdaleæ, Coriariaceæ; and the genera Aconitum, Aquilegia, Draba, Euonymus, Geum, Ribes, Chrysosplenium, Hieracium, Gentiana, Iris, Lilium, Fritillaria, and Veratrum. To the foregoing may be added the genera Orchis, Ophrys, and Daphne, which are represented in the Atlas mountains, as well as in Europe and Asia. Of South African elements wanting, the following are named :—Cunoniaceæ, Bruniaceæ, Penæaceæ, Stilbeæ, Restionaceæ, Diosmeæ except Calodendron, all Proteaceæ except Protea and Leucospermum [probably a slip for Faurea.—W. B. H.], and the genera Muraltia, Aspalathus, Cliffortia, and Phylica.

Vegetation of Lagoa Santa.—Under the title "Et Bidrag til den Biologiske Plantegeografi," **E. Warming** has published (*Mem. Acad. Roy. Denmark* [6], vi.) a very elaborate description of the vegetation of Lagoa Santa, Brazil, in about 20° S. lat. There are numerous illustrations of the habit and mode of growth and propagation of the characteristic elements in the vegetation of various regions. A French summary is appended, and the whole work occupies nearly 500 quarto pages, forming an important contribution to plant-geography.

Orchids.

Manual of orchidaceous plants.—**James Veitch and Son's** useful publication has reached the eighth part, which treats of the large genus Oncidium and the smaller genera Miltonia, Brassia,

Ionopsis, Gomeza, Ada, and Ornithocephalus. The genus Oncidium alone numbers between 200 and 300 species. Indeed, upwards of 300 have been published, but some are doubtless mere colour varieties, and others have been described under different names by different botanists. Messrs. Veitchs' work offers an immense amount of practical knowledge combined with scientific precision.

Masdevallia.—The third part of **Miss Woolward's** illustrated monograph of this genus has appeared. It contains the following species:—M. Arminii, Carderi, caudata, coccinea, coriacea, Davisii, Estradæ, polysticta, triangularis, and Wageneriana. The first and next to the last are here figured for the first time. This work is issued by the Marquis of Lothian. It is to be hoped that following parts will appear at shorter intervals.

"Xenia Orchidacea."—The late Dr. Reichenbach's work under this title is being continued by **F. Kränzlin**, and the sixth part of the third volume has lately been issued. It contains ten partly coloured plates, illustrating several old species and the following new ones:—Catasetum Liechtensteinii, Lælia Reichenbachiana, Cœlogyne Micholieziana, Octomeria Seageriana, Rœperocharis Urbaniana, R. alcicornis, Pholidota Laucheana, and Dendrobium listeroglossum, all of which are of botanical rather than horticultural interest.

Habenaria.—**F. Kränzlin** has monographed this genus (*Engler's Botanische Jahrbücher*, xvi.) as he limits it—that is to say, excluding Platanthera, referred to it by some authors. Thus restricted he describes 348 species, which he classifies under 34 sections. [*See* also below FIGURES OF PLANTS.]

Figures of plants.

Specially interesting among the plants figured in the *Botanical Magazine* are:—Hydnophytum Forbesii (plate 7218), one of those singular epiphytic plants having large tuberous rootstocks pierced by numerous passages and galleries, in which colonies of ants find their abode; Neobenthamia gracilis (plate 7221), a new genus of orchids with long, flexible stems and small white flowers, from tropical Africa; Cereus giganteus (plate 7222), the giant cactus of Arizona and North Mexico, where in desert regions it sometimes attains a height of 60 feet—a specimen about 14 feet high flowered in the palm-house at Kew; Cirrhopetalum ornatissimum (plate 7229), an exceedingly pretty species, near C. Collettii; and Rosa pomifera (plate 7241), as the name denotes, has a very large fleshy fruit, and it is one of the most ornamental of the single roses. This rose often exhibits a peculiarity, shown

in the plate cited, though not mentioned in the description, namely, the flowers often develop in twos, and the fruit in each pair is dissimilar. One of the two is pear-shaped on a very short stalk which is thickened, fleshy, and coloured and tapering to the base, while the other is globose or ovoid and borne on a green stalk as long as itself and of the same thickness throughout. Synandrospadix vermitoxicus (plate 7242) is a very remarkable aroid from Tucuman. Finally, Monodora grandiflora (plate 7260), a West African anonaceous tree having large, pendent yellow and red-brown flowers with long wavy petals, recalling some of the larger Oncidia."

Hooker's Icones Plantarum.—The Bentham Trustees are issuing this work at the rate of one volume of 100 plates a year. Vol. i. of the fourth series, devoted entirely to the illustration of Indian orchids, has been completed; and the first part of vol. ii., likewise devoted to Indian orchids, has appeared. Most of the orchids figured are of the less showy kinds. Parts 1 and 2 of vol. iii. have also been published. The contents of this volume are of a miscellaneous character, and some of the plants figured are of great interest:—Phtheirospermum tenuisectum is a second species of the genus inhabiting the mountains of Tibet and Western China; Strychnos Ignatii and S. multiflora from the Philippine Islands, with an account of the source of the St. Ignatius's Bean; Coriaria terminalis, a distinct new species from North-Eastern India and Western China; Trichomanes Sayeri, a pigmy species from Queensland with fronds $\frac{1}{8}$ to $\frac{1}{6}$ of an inch long; Ixora siphonantha, a Madagascar species having yellow flowers 9 or 10 inches long; Pleurospermum Franchetianum, a showy umbellifer from Western China; Didymocarpus pectinata, a curious Malayan plant with fern-like leaves; and Tetrachondra Hamiltonii, a singular new genus of Boragineæ, resembling Tillæa, recently discovered in New Zealand.

(*See* also under Australia and Polynesia.)

Miscellaneous.

Coniferæ.—The Conifer Conference Report (*Journ. Roy. Hort. Soc.*, xiv. 179) contains much of interest concerning this family of plants, especially in synonymy and bibliography. **M. T. Masters** contributes a "List of Conifers and Taxads in cultivation in the open air in Great Britain and Ireland." "Taxads," it may be explained, comprise the yews and their allies. Independently of the information it contains—for it is very much more than a list—this is an excellent guide to the literature of the subject. The author advocates and adopts familiar current names, where not absolutely incorrect, in preference to altering or resuscitating

names in accordance with the rule of strict priority. In this course he will doubtless receive the support and approbation of the majority of horticulturists. Dr. Masters also delivered an introductory address on "Some Features of Interest in the order of Conifers." There are several other interesting and useful papers in the same volume, notably the "Pinetum Danicum," by **Carl Hansen**, which covers nearly 250 pages, and is a compendium of information. "The Conifers at Dropmore," by **C. Herrin**, contains particulars of the size, age, and history of many of the fine specimens in that unrivalled collection. There are several very fine Araucarias at Dropmore, but the finest, which was planted in 1830, is 68 feet 6 inches high, with a girth at three feet from the ground of 8 feet 3 inches, and a spread of branches 38 feet in diameter sweeping the ground. Abies Douglasii, planted in 1830, is 120 feet high, and 11 feet 4 inches in girth. A cedar of Lebanon planted in 1792 is 104 feet high, and nearly 14 feet in girth. Cedars are a great feature at Dropmore. An avenue of 140 trees, planted about eighty years ago, average 85 feet in height. The tallest Wellingtonia is 67 feet high, with a girth of over 12 feet. There are copious statistics of the dimensions of trees from numerous estates in all parts of the kingdom, but although several trees are recorded over 100 feet high, the Abies Douglasii at Dropmore is the tallest of all.

The Irideæ.—**J. G. Baker** has followed up his English monographs of the Amaryllidaceæ and Bromeliaceæ with a "Handbook of the Irideæ." These "handbooks" are specially valuable to horticulturists who care for correct nomenclature. Mr. Baker has arranged the Irideæ under 57 genera, some of which present a long array of species. For example, Iris numbers 161 species, Gladiolus 132, Crocus 66, Ixia 24, Sisyrinchium 58, Romulea 33, Moræa 57, and Lapeyrousia 32.

The Malveæ.—**E. G. Baker** is continuing (*Journ. of Bot.*, 1892) his revision of this very much involved tribe. Reduction of the synonymy constitutes the most laborious part of the work.

Kew bulletin of miscellaneous (botanical) information.

In addition to the usual articles on the sources of vegetable products, many of which are of great value, this publication now includes descriptive and taxonomical matter. **J. G. Baker's** "Notes on the Agaves and Arborescent Liliaceæ on the Riviera" are of great practical value, as they are the fuller development of a special knowledge of this class of plants. Synonymy is one of the features of the notes. A new departure is the publication of decades of descriptions of new plants that are constantly turning

up in the collections of dried plants received at Kew. There are also separate decades of descriptions of new cultivated orchids.

MORPHOLOGY AND BIOLOGY OF PLANTS.

BY G. MASSEE.

A SURVEY of the work produced during the year, which is very considerable, shows a preponderance of laboratory investigation that in many instances illustrates the modern feeling, entertained by many, that plant affinity can be more accurately indicated by minute internal structure than by the sum-total of morphological and biological features; a feeling due in great measure to the fact that many teaching centres have but a very limited supply of living plants, and consequently depend on dried or spirit material.

Karsten's important work on Gnetum will, if corroborated, necessitate some important modifications of the generally accepted view of the embryogeny of phanerograms. The theory advocated by Bower for connecting the muscineae with the vascular cryptogams appears feasible, and has suggested a new line of research, the investigation of which will doubtless furnish more evidence in support of the theory. Ward's investigations on the nature of the "ginger-beer plant" illustrate the fact that hitherto unknown organisms, living in symbiotic communities, may be present in well-known, but hitherto uninvestigated forms of life.

PHANEROGAMS.

Morphology.

G. Karsten has recorded some very remarkable discoveries in the embryology of East Indian species of Gnetum, G. edule, G. gnemon, G. neglectum, and three new species.

The innermost coat of the nucellus protrudes beyond the others, and secretes a drop of fluid at its apex, which arrests the very small pollen grains that are borne by the wind or possibly by insects. The pollen-tube is nourished during its growth by the disintegrated cell-substance. The outermost coat of the ovule becomes fleshy and bright-coloured, and attracts herbivorous animals. During the early stage of division of the nucellus there is no distinguishable mother-cell of the nucellus, as in most angiosperms. In G. gnemon and G. neglectum, two to several embryo-sacs are present, whereas in G. edule and the other forms only one was seen.

During the division of the embryo-sac there is no differentiation, special egg-cells, corpuscles, nor antipodal cells, and the primordial cells of the parietal layer appear to be all equally capable of impregnation, and hence represent so many oospheres.

Soon after the entrance of the pollen-tube into the tissue of the nucellus its nucleus divides into two; one of these, the vegetative nucleus, remains unchanged, the other, or generative nucleus, increases in size, and ultimately divides into two perfectly identical generative nuclei. After the pollen-tube has entered, or become closely applied to the embryo-sac, the vegetative nucleus disappears, and the two generative nuclei become separately clothed with a layer of protoplasm, and then constitute generative cells.

The next observable change is the segmentation of the nucleus of each generative cell into four or probably eight nuclei, which remain in the unsegmented mother-cell. Contemporaneous with this division of the nucleus, one or several smaller nuclei appear in the protoplasm of the generative cell; these are supposed by the author to be female nuclei that have passed from the primordial cells of the parietal layer of the embryo-sac. At a later stage only four or eight nuclei are present in each generative cell. Karsten considers that this is due to the fusion of the male and female nuclei previously present in the cell; the coalescence of the supposed male and female nuclei was not actually observed.

After impregnation the parietal protoplasmic layers of the embryo-sac, also that portion of its central vacuole not occupied by the male cells or the embryos, become replaced by endosperm tissue. This fact the author considers to prove that Gnetum represents the highest type of gymnosperms.

It is further considered that the appearances described disprove the theory that the antipodal cells are the last remnants of the prothallus of vascular cryptogams; these structures being looked upon by Karsten as the remains of a now obsolete female sexual structure. (*Bot. Ztg.*, 1892, nos. 13–15.)

D. T. MacDougal (the Tendrils of Passiflora caerulea) has investigated the morphological structure of the tendrils for the purpose of determining the factors connected with movements, more especially those movements by which a tendril responds to a stimulus. Three distinct regions are recognised in a tendril: the basal or non-coiling portion, 3–4 cm. in length; the middle or coiling region, comprising the greater part of the organ, which is generally slightly curved; and the sharply-curved tip, 4–6 mm. in length. These three regions exhibit marked differences in structure and outline. The internal structure of the three parts

shows corresponding differences. The whole organ shows a bilateral structure, most pronounced in the portion having the greatest power of movement. The epidermis consists of a layer of rectangular cells arranged with their longest diameter parallel to the long axis of the tendril. All the tissues of the tendril are abundantly supplied with pits.

The conclusions are—that the concentration of protoplasm in the epidermal layer is directly connected with irritability; that the movements are due to changes in the chlorophyll layers; and that the abundant supply of reserve food material is for the purpose of favouring rapid growth and fixation of the tendril upon coiling. (*Bot. Gazette*, xvii. 205.)

M. F. Ewart contributes an exhaustive account of the morphology and service in the mechanism of the flower, of groups of hairs, associated with the stamens, in the genus Thesium. These structures, termed "staminal hairs," spring from the inside of the perianth-tube at about the level of the insertion of the stamens, and the majority proceed from ten groups, one placed on either side of each stamen. The hairs appear to be unicellular, each consisting of two portions: an enlarged basal cushion, sunk below the level of the perianth, and a continuous, slender, projecting portion, exhibiting near the apex three remarkable constricted rings, and a small, rounded, terminal cap. The above is the arrangement and structure of the hairs in Thesium capituliflorum. Two varieties of these hairs are met with, some directed towards the base of the style; others, more slender and elongated, are directed upwards towards the top of the anther, and in many instances are firmly fixed by a viscid secretion from the hairs to the anthers. The correlations of the other structures of the flower with the modifications of the hairs, appear to suggest that their function is that of aiding in pollination, either by collecting pollen, or serving as guides to insects visiting the flower.

A proposed classification of the genus Thesium, based on the structure of the flower, is also elaborated. (*Ann. Bot.*, vi. 272.)

On the nature and development of the corky excrescences on stems of Zanthoxylon.

C. A. Barber calls attention to the corky outgrowths present on the branches and trunks of certain trees. These excrescences are frequently of large size and very symmetrical in shape, and are characteristic of Zanthoxylum, though by no means confined to this genus. These bodies originate as corky cushions beneath thorns or spines, and it seems probable that in most cases their function

is the retention of the thorns—at any rate in the young plant—after secondary thickening has commenced. In climbing plants, as Caesalpinia nuga, where the stem increases but little in thickness, the corky cones are of great length, and thus extend the circle of operations of the persistent curved spines at their tips, as protective organs or for purposes of climbing

In other cases, as illustrated by the roses, the corky layer at the base of the thorns enables the latter to be readily pulled off; and it is suggested that the readily separable thorns may penetrate climbing animals and be borne away by them. (*Annals of Bot.*, vi. 155.)

F. Pasquale propounds a new theory of the morphology of the carpel, suggested by a critical examination of the course of the vascular bundles, especially in the Cruciferæ, Sterculiaceæ, and Leguminosæ. According to this author the carpel is composed of three leaves so completely fused together that the mesophyll and epidermis of the components are continuous, the ultimate ramifications of the vascular bundles also anastomose. The structure is called a triphyllome, and consists of two fertile posterior leaves, and one sterile anterior leaf, which is sometimes entirely absent, and when present occupies the dorsal side of the carpel, and is usually reduced to a single vascular bundle. The two fertile leaves are flattened and furnished with vascular bundles, and are united to each other by their respective midribs. One half—or hemiphyllome—of each leaf forms the pericarp, also the septa in a syncarpous fruit, the two remaining hemiphyllomes project into the cavity of the carpel and form the placental structure, which includes the placenta as generally understood, the funicles, style, and stigma.

The replum in Cruciferæ is considered as an extension of the placental structure. The presence of two stigmas in many monocarpellary fruits in Graminaceæ, Compositæ, and Leguminosæ is considered to originate from the two fertile leaves of the carpel. (*Bull. Soc. Bot. Ital.*, 1892, p. 26.)

P. H. Rolfs has investigated the development of the seed-coats in 22 genera and 34 species belonging to Malvaceæ. The seed-coat is composed of two integuments; in the course of development the cells of the outer integument undergo but little differentiation, simply increasing in size. More decided changes take place in the inner integument; the first layer of cells lengthens out radially until each cell is nearly three times as long as broad; these cells form the palisade layer so characteristic of the order.

The number of integuments in the different species studied

was the same, and the number of layers in each integument also practically the same. (*Bot. Gazette*, xvii. 33.)

J. Grüss has shown that the chief use of the outer covering of dormant leaf-buds is a protection against an excess of transpiration, the special preventives being formation of cork, an excretion of resin, or a coating of hairs. These developments also guard against the injury that might be occasioned by a sudden fall of temperature. In many instances the parenchymatous cells of bud-scales contain food materials, chiefly in the form of carbohydrates. (*Pringsheim's Jahrb.*, xxiii. 637.)

Biology.

C. V. Riley has brought together a series of observations, extending over nearly twenty years, on the pollination of the species of Yucca. The flowers all agree in having the stamens so inserted that fertilisation unaided can take place only by the merest chance. Yuccas are amongst the few plants dependent on a single species of insect for pollination, and they actually depend on some particular species of little white moths belonging to the genus Pronuba. Yucca filamentosa, and all species found east of the Rocky Mountains depend for pollination on the common Yucca moth, Pronuba yuccasella. During the day the moth may be found resting within the half-closed flowers, where it is hidden from ordinary view, and also well protected by the imitative colour of the front wings with that of the flower. At night, when the perfume of the flowers is strongest, the moths may be seen flitting from flower to flower. The female performs the function of pollination, and after collecting a considerable quantity of pollen from one flower usually flies with its load to another plant, cross-fertilisation being thus secured. After selecting a suitable flower the moth next proceeds to deposit its eggs in the ovary, an act at once followed by thrusting its cargo of pollen into the stigmatic opening, and thus effecting pollination. It is chiefly during the first or second nights after opening that the flower is susceptible of pollination, and the moths seem to be aware of this, as they are never found laying their eggs in older flowers; in fact the actions of the moth suggest a close investigation, not only as to the condition of development of the pistil, but also as to whether eggs have been already deposited. This precaution is necessary, inasmuch as if the eggs were deposited in an ovary where pollination could not be effected, the seeds on which the larvæ of the moth feed would not be formed.

The larva matures with the seeds, and when the latter are

nearly ripe bores through the fruit, and buries itself in the ground. The number of seeds destroyed rarely exceeds a dozen, although as many as twenty-one larvæ have been found in a single pod. The pods become depressed at those points where the eggs were deposited, and these irregularities have been considered characteristic of the fruits of the genus. When pollination is effected artificially, and the flowers protected from Pronuba, no depressions occur on the fruit.

The author considers, from observations on various living species of Yucca, and also from an examination of the fruits preserved in herbaria always showing constrictions or perforations made by the larvæ in their exit from the fruit, that all are dependent on some species of Pronuba for pollination, and that when the visits of the moth are not received seed is never produced. (*Missouri Bot. Garden*; Report, 1892, p. 99.)

D. Prain ("The Vegetation of the Coco Group," *Jour. Asiat. Soc. of Bengal*, lx., part ii., No. 4, p. 283), in discussing the probable origin of the floras of the group of islands under consideration, has some extremely interesting remarks on the various modes of seed and fruit dispersion.

It is considered that the agency of wind may easily be over-rated, and that the fruits or seeds of many species well adapted for transmission by wind can only assist in local dispersal. Birds are credited as dispersive agents, by very varied means, of plants of aquatic or paludine habitat, and characterised by small inconspicuous fruits or seeds that might become attached along with mud to the feet, leg-feathers, or the feathers at the base of the bill, of birds frequenting pools and swamps. A second kind of species may be transported from place to place by becoming attached externally to birds. Other species of plants characterised by having pulpy fruits with a hard stone or with hard, indigestible seeds, may be disseminated by birds eating the fruit and voiding the seeds at a distance. It is also shown that certain species of plants, the fruits or seeds of which are eaten, not for the sake of a pulpy portion, but on account of the nutritious properties of the whole fruit or seed, may be dispersed by birds. Under ordinary circumstances such food would be digested, but it is not unusual for migrant birds to arrive in a very exhausted condition, or to be driven by severe cyclones to new islands, where some perish from exhaustion, or fall victims to birds or beasts of prey, the fruits or seeds that their crops may contain falling aside and germinating. Evidence is given to show that there is nothing extravagant in claiming this as a possible means of plant dispersion.

Finally, ocean-currents are important factors in the dissemination of plants, more especially in tropical regions.

The following abridged synopsis of the origin of the Coco Island flora will give some idea as to the relative importance of the various agencies concerned with plant dissemination.

Species possibly introduced, for the presence of which no former land connection need be necessary	288
Introduced by human agency	33
Introduced by birds (perhaps also to a small extent by bats)	94
By wind	60
By the sea	101
Species probably remanent and indicating former connection with adjacent land	70
Total of Coco Island species	358

M. A. Prunet has given an explanation of the well-known fact that the buds located on the upper (anterior) half of a potato grow earlier and more vigorously than those on the lower (posterior) half. When young, the nutritive material is equally distributed throughout the tuber, but at a later stage becomes more concentrated at the upper end, hence the buds in this region are better supplied with food-material. The bearing of this fact on the usual practice of cutting up potatoes for planting is obvious. (*Comptes Rendus*, cxiv. 1079.)

S. Coulter announces the presence of cleistogamous flowers (inconspicuous flowers that never open, and are self-fertilised) on many species of Polygonum, including H. hydropiper, H. lapathifolium, H. maritimum, and H. persicaria. These flowers are developed late in the season, are completely hidden by the leaf-sheath, and always mature their seeds. (*Proc. Acad. Nat. Sci. Phila.*, 1892, p. 163.)

A. Goiran finds that the effects of earthquakes on plant life are mainly beneficial, thus seeds germinate more rapidly, the vegetation is more luxuriant, and the foliage of a darker green than usual. These results are considered to be due to secondary causes: (1) The increase in quantity of carbon dioxide; (2) the distribution of nutritive fluids through the soil; (3) the production of electricity, which favours a high stage of vegetable development. (*Bull. Soc. Bot. Ital.*, 1892, p. 109.)

VASCULAR CRYPTOGAMS.

Studies in the morphology of spore-producing members.

F. O. Bower, in a preliminary statement on the Lycopodinæ and Ophioglossaceæ, after pointing out the current idea that the

sporophyte in archegoniate plants is the result of elaboration of the zygote, says that in certain Algæ the zygote divides to form a number of carpospores; in the lower bryophyte the tissue of the zygote undergoes differentiation, an external portion remaining sterile, and forming a protective wall, enclosing a central mass of sporogenous or spore-producing tissue. In the higher bryophyta (mosses) there is a yet larger proportion of sterile tissue, differentiated into seta, columella, sporangial-wall, etc., the comparatively small amount of sporogenous tissue still forming one united band.

In the vascular cryptogams the above idea of progressive sterilisation of the tissue of the zygote is yet more marked, the quantity of sporogenous tissue being very small in proportion to that of the sterile tissue, and the latter by progressive elaboration of external form and internal structure—the two lines of progress going, in a measure, hand in hand—has resulted in the formation of appendicular organs, one result being the breaking-up of the one continuous band of sporogenous tissue, as seen in the bryophyta, into small, isolated masses, or even single cells, these being situated in the parts usually called sporangia.

Based on observed facts in the lower cryptogams, relative to the gradual sterilisation of the tissue of the neutral generation and its progressive differentiation, accompanied by the breaking up of the sporogenous tissue into minute, isolated portions, the author puts forward the theory that the "fertile frond" in Ophioglossaceæ is an elaborated and partitioned sporangium, homologous with the smaller and non-partitioned sporangium of the Lycopodinæ; the central tissue of the "fertile frond" corresponding to the sub-archesporial mass of the sporangium of Lycopodium, and the whole illustrating the result of partial sterilisation, elaboration, and consequent partitioning of the sporangium.

Developmental evidence in support of this theory was derived from an examination of the structure and development of the sporangium in several species of Lycopodium on the one hand, and of Ophioderma, Helminthostachys, and Ophioglossum, on the other.

The widest gap among plants having sharply-defined alternation of generations is that between the bryophyta and the vascular cryptogams; in other words, between those plants having a simple "fruit" and the sporogenous tissue in one continuous band, and those with complex "fruit" and with the sporogenous tissue in small, isolated portions.

The author considers that acceptance of the above theory

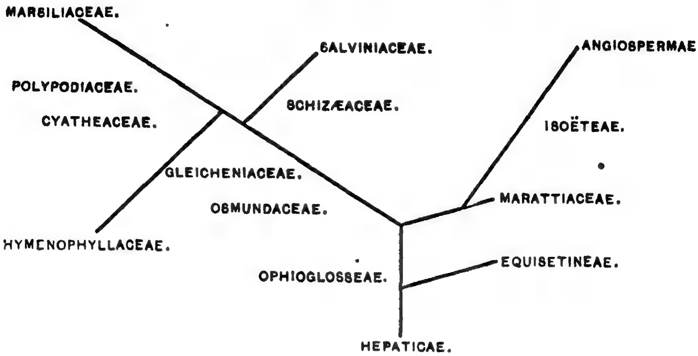
may lead to a bridging over of the above-named gap. For example, following the lines of evolution indicated above, it is not difficult to see how, from one of the bryophyta, like Anthoceros, the cone-like "fruit" of Equisetum or Lycopodium might originate, by the breaking-up of the continuous band of sporogenous tissue in Anthoceros into isolated portions, as in Ophioglossum, and continue its elaboration by the outgrowth of new members from the surface, as in Helminthostachys. (*Proc. Roy. Soc.*, l. 265.)

D. H. Campbell ("On the Prothallium and Embryo of Osmunda Claytoniana, L., and O. cinnamomea, L.") gives a detailed account of his investigations on the two above-named species. The spores of both germinate immediately, and form a prothallus as in the Polypodiaceæ. A single two-sided apical cell appears early, which gives place to a single nearly-square one and finally to a row of marginal initials. In O. claytonia the prothallium branches abundantly, and adventitious prothallia are formed in both species. The chloroplasts are sometimes of extraordinary size in O. cinnamomea. The antheridia differ in structure from those of other ferns, and approach most nearly those of the Hymenophyllaceæ and Gleicheniaceæ. The spermatozoids resemble most nearly those of Equisetum. Stem, leaf, and root grow from a tetrahedral apical cell, which is one of the original octants of the embryo. The foot is very large, and the embryo is for a long time dependent upon the prothallium for food; the calyptra is also large; these features, along with the late differentiation of the tissue-systems, are considered as evidences of the primitive character of the Osmundaceæ.

The author considers the eusporangiate ferns (those with the sporangium developed from several cells) to be the primitive forms, and this idea is supported by geological evidence.

The simpler living Ophioglosseæ may probably resemble the primitive ancestral forms from which the other ferns have sprung; from this primitive stock it is assumed that the Equisetineæ originated at an early stage, and later the Marattiaceæ. From the latter probably arose forms like Isoetes, from which in turn the angiosperms developed. A third form, the leptosporangiate ferns (having the sporangium developed from a single epidermal cell), evolved from the Ophioglosseæ through forms like Botrychium and Osmunda, and constitute the great bulk of ferns living at the present day.

The relationships of the various groups, as assumed by the author, are represented in the following diagram. (*Ann. Bot.*, vi. 49.)



BOTANICAL PEDIGREE.

M. G. Poirault calls attention to a few points of structure in Ophioglossum vulgatum, hitherto unobserved. (*Jour. de Bot.* [Morot], vi. 69.)

J. Bretland Farmer has contributed some observations on the embryogeny of Angiopteris evecta Hoffin. (*Ann. Bot.*, v.–vi. 265.)

Muscineæ.

R. Coesfeld has some observations on the anatomy and physiology of Polytrichum commune. The epidermis consists at first of a single layer of cells; these afterwards divide by tangential cells. The cortical tissue consists of elements resembling bast-cells in form, and during the spring contain tannin. The cells of the central bundle are much elongated, their length being due to tension or stretching; the central bundle must be considered as a primitive vascular-bundle, the cells containing oil and starch-grains in the spring, and its function appears to be that of storing and conducting food-material much more than that of conducting water. The cells of the central bundle alone give a pure cellulose reaction. No evidence of lignification was detected in any part of the structure. (*Bot. Ztg.*, 1892, p. 153.)

F. Stephani has some interesting notes on the morphology and physiology of the leaf-lobule in certain members of the Hepaticæ. (*Jour. Linn. Soc.*, v. 29.)

Algæ.

M. L. Guignard has given a very full account of the muciferous tissue present in the members composing the Laminariaceæ. Laminaria Cloustoni was the species used in the researches embodying the origin and development of the mucus-canals. These bodies are absent in a fully developed form in the generating zone

connecting the perennial basal portion of the alga and the annual lamina; nevertheless, the canals originate at this point, and spread to the lamina and stipe respectively. Their first appearance is that of lenticular cavities in the radial walls of the epidermal cells, which soon become filled with mucilage; at a later stage the mucus-canals give off branches, which anastomose with each other, thus forming an irregular network. This network approaches the surface of the frond, but never pierces the cuticle, hence the mucus is never liberated at the surface of the frond.

The author considers that specific, but not generic characters may be furnished by the presence, absence, and localisation of these mucus-canals. (*Ann. Sci. Nat.* [Bot.], xv. 1.)

Edw. A. L. Batters describes a new genus of marine algæ—Schmitziella—belonging to the order Corallinaceæ. The genus is especially interesting on account of the morphological peculiarities presented, which differ considerably from those typical of the order to which it belongs. It is an endophyte, developing in the thick, laminated cell-wall of Cladophora pellucida, its presence being indicated by the beautiful red colour communicated to the stem of the host; the thin red walls of the thallus do not contain a trace of chalk; finally there is an absence in all but the most rudimentary form of the enclosing wall with which the reproductive organs of all the other known Corallinaceæ are surrounded.

The reproductive organs occur in sori—closely compacted clusters—scattered over the surface of the frond which is located in the substance of the cell-wall of the host. On the tetrasporic sori the outermost layers of the wall of the host are ruptured by the protrusion of a central bundle of sterile filaments, or paraphyses; the same object is affected for the cystocarpic sori by the protrusion of the trichogynes. A margin row of filaments, usually composed of short two-celled threads, always remains sterile, forming a ring around the empty sorus; this represents in a very rudimentary form the enclosing wall in which the reproductive organs of the other members of the Corallinaceæ are developed; hence Schmitziella illustrates the transition from the unenclosed sorus to the conceptacle. The only known species—Schmitziella endophloea—occurs on the English and French coasts. (*Ann. Bot.*, vi. 185.)

R. J. Harvey Gibson has described and figured the hitherto unknown cystocarpic fruit of Catenella opuntia, which is shown to differ from the usual floridean type in several respects The trichophoric systems are very numerous, yet only one cystocarp is produced; fertilisation is indirect, the carpospores being

developed in chains from the medullary network of cells, and not from the cells immediately beneath the trichogyne, the two sets of cells being, however, in organic continuity. (*Linn. Soc. Jour. Bot.*, xxix. 68.)

Phycological memoirs.

The first part of this new publication contains the following papers:—

On Splachnidium rugosum, Grev., the type of a new order of Algæ. **Margaret O. Mitchell** and **Frances G. Whitting.**

This alga has only one known kind of fruit, which it is suggested may be: (1) oogonia containing a large number of small oospheres; (2) large antheridia; (3) sporangia like those of the Laminariaceæ, containing zoospores. These three possibilities considered as lying outside the range of probability, it is stated that "there is no other course open to us than to establish one (natural order) for its reception under the name of Splachnidiaceæ, the main character of which shall be *reproduction by spores contained in sporangia which are borne within conceptacles.*"

On the structure of Dictyosphæria Decne.

G. Murray. The component cells of the thallus are not organically joined, but held together mechanically by discs or tenacula, produced at the ends of more or less elongated filaments. In Dictyosphæria favulosa a collection of unbranched cells or units are united by tenacula into a colony; this is considered as representing the most reduced type of siphoneous thallus.

On malformations of Ascophyllum and Desmarestia.

Ethel S. Barton. The gall-like swellings on the thallus have been found to contain nematodes and minute copepods, but under what conditions these creatures obtain access to the interior of the frond was not determined [hence it has yet to be demonstrated whether the galls are caused in the first instance by such animals as those named above, or by bacteria, as advocated by Schmitz]. (*Brit. Assoc.*, 1892.)

On Conchocelis, a new genus of perforating algæ.

E. A. L. Batters. This minute alga, growing in the substance of various shells, indicates its presence by a pink stain on the surface of the shell. It is supposed to belong to the Porphyraceæ, and on this account is interesting, all previously known perforating algæ belonging either to the Cyanophyceæ or the Chlorophyceæ.

J. B. Carruthers has examined the cystocarps of certain species of Callophyllis and Rhodymenia, and concludes that the develop-

ment of the fruit in Callophyllis obtusifolia differs from the account given by Agardh for this species; and on the other hand agrees in the main with the mode of development of the cystocarps in Gymnogongrus and Callymenia, described by Bornet; and those of Gigartina and Chondrus, as described by Schmitz. (*Linn. Soc. Jour.*, xxix. 77.)

T. Huber and **F. Jadin** have discovered a new perforating alga in streams near Montpellier, belonging to the Cyanophyceæ, and which is to be hereafter known as Hyella fontana. It is closely allied to Hyella cæspitosa Born. and Flah., also a perforating alga, living in the shells of marine molluscs, whereas the present species lives in the old shells of molluscs, and also in the calcareous stones forming the bed of clear, well-aerated rivers and streams.

On rocks, where it is most abundant, the alga penetrates to a depth of 1–2 mm., and forms extended layers, imparting to the stones a greenish-grey to a bluish-green colour. The alga is composed of branched filaments formed of cells with homogeneous contents and destitute of a nucleus. All the superficial vegetative cells are capable of becoming transformed into reproductive cells or sporangia, by repeated division of their protoplasm. The filaments eventually replace nearly all the chalk at the surface of the stone, and as this takes place the deep-seated filaments of the Hyella penetrate lower and lower, thus causing a slow but continuous disintegration of the substratum.

The attention of palæontologists is called to the fact that all the perforated shells and stones were found in quick-running, clear, rather shallow water. This remark might perhaps serve to indicate the conditions of life and the deposition of certain fossiliferous deposits. (*Jour. Botanique* [Morot], Aug., 1892.)

Fungi.

M. C. Van Bambeke. from an examination of numerous species belonging to 44 genera, illustrating the most varied forms included in the Agaricineæ, concludes that "vascular hyphæ"—the name adopted for the older terms, laticiferous vessels, oleiferous vessels, sap-ducts, etc.—are probably present in all the Agaricineæ. The vascular hyphæ may be present in either stem, pileus, or hymenium, depending on the particular species, and from the variable nature of their form, arrangement, and contents, might be utilised as factors in classification. The contents of the vascular hyphæ are complicated, and amongst other substances present are—fatty matters and glycogen, which suggest that one function is the distribution of food material; and as the organs frequently terminate externally between the elements of the hymenium, it is assumed that they may perform other functions of elaboration

and excretion. [It has been shown, **G. Massee**, *Jour. Linn. Soc.*, xxv. 119, that these organs excrete oxalate of lime.] (*Bot. Jaarb.* [*Zeut.*], iv. 1892, p. 176.)

Harold Wager ("On the Nuclei of the Hymenomycetes") gives a preliminary account of some observations on the nuclei of the basidia of Agaricus (Stropharia) stercorarius. The young basidia, in this and other species of agarici, contain two nuclei, which appear to pass into the basidium from the hymenial hyphæ. At an early stage the two nuclei fuse together and form a single large nucleus, which is situated near the centre of the basidium, and finally takes up a position near the apex of the basidium. The structure of the nucleus resembles that of the higher plants, consisting of a nuclear membrane, enclosing a dense nucleolus and a thread-like network. Previous to the formation of the sterigma the nucleus divides, first into two, then into four. The four nuclei now pass to the base of the basidium and come into close contact. When the four sterigmata are formed at the apex of the basidium the nuclei separate, and each nucleus takes up a position at the base of one of the sterigmata. The passage of the nucleus through the sterigma into the spore at its apex was not observed, but it was ascertained that the spores do not contain a nucleus until after the formation of the thick spore-membrane. When the spores are mature they contain two nuclei. (*Ann. Bot.*, vi. 146.)

Alfred De Wevre describes some very interesting experiments made on Phycomyces nitens. The spores will not germinate in distilled water nor in ordinary water, neither in sterilised water containing any of the following substances in solution: oxalic acid, 1 per cent.; chloral, 1 per cent.; chloral, 0·5 per cent.; tartaric acid, 1 per cent. On the other hand, Penicillium glaucum develops perfectly in a 1 per cent. solution of tartaric acid. Solar light, other things being equal, retards the growth of the fungus. Under certain special conditions the hyphæ become transversely septate or very much swollen. ("Recherches expérimentales sur les Phycomyces nitens [Kunze]." *Bull. Soc. Roy. Bot. Belg.*, xxx. 107.)

Alfred De Wevre announces the presence of nuclei in several fungi belonging to the Mucorineæ. The nuclei are very minute, rounded or fusiform, and immersed in the protoplasm. As a rule each spore contains only one nucleus, whereas in the tubes they are always plentiful and sometimes very numerous. The nuclei multiply by division. The best preparations resulted from the use of picronigrosin. ("Le Noyau des Mucorinées," *Bull. Soc. Roy. Bot. Belg.*, xxx. 191.)

Roland Thaxter ("Further Additions to the North American Species of Laboulbeniaceæ," *Amer. Acad. Arts and Sci.*, 1892, vol. xiv. 29) describes three new genera and several new species of North American Laboulbeniaceæ that have been discovered since the publication of the same author's very beautiful monograph, "The Entomophthoreæ of the United States." (*Mem. Boston Soc. Nat. Hist.*, iv., num. vi., 133, 8 pl., 1888.)

W. A. Setchell ("An Examination of the Species of the Genus Doassansia, Cornu," *Ann. Bot.*. vi, 1, 2 pl.) describes in detail the morphology and affinities of the species of Doassansia. Five new species are described.

M. C. Cooke ("Handbook of Australian Fungi"). This book is published under the auspices of the various Australian Governments, and contains descriptions of all known Australian and Tasmanian fungi, numbering 2,084 species. It contains 36 plates, 20 of which are coloured.

Effect of movement upon the growth of lower organisms.

H. L. Russell has given the results of a series of experiments for the purpose of ascertaining (1) what influence mechanical movement has upon growth of cells in regard to size and form; (2) its influence upon growth in regard to increase in number. The species experimented upon were—Monilia candida, Oïdium albicans, and Saccharomyces mycoderma. Two flasks containing sterilised nutrient solutions were inoculated with a known number of cells of the organism to be experimented upon, and were then subjected to exactly the same conditions, with the exception that one of them was kept in a constant state of agitation by specially-arranged machinery. The results show that continuous movement has but little effect on the form and size of fungal cells; but hyphæ are much retarded in development. On the other hand, agitation greatly favours the increase in number of cells, and consequently the amount of organic matter produced. The increased growth in agitated cultures as compared with still-grown cultures is usually 200–300 per cent. The amount of fermentation products, as determined by the alcohol formed, is uniformly less in agitated than in still cultures.

The cause of the more rapid cell-formation by mechanical movement is considered to depend upon aeration of the culture, the cells growing more rapidly in contact with atmospheric oxygen than when submerged; better conditions of nutrition, etc., are probably also less important factors. (*Bot. Gazette*, xvii. 8.)

Lichen-forming fungi.

M. P. Hariot has examined the so-called genera Dichonema,

Rhipidonema, and Laudatea, and concludes that all must be included under the generic name of Dictyonema. It is further stated that the last-named genus is a true lichen, and that all described species are but forms of one, D. sericeum. The fungus belongs to the Hypochnaceæ, and probably to the genus Coniophora; the basidia are tetrasporous (bearing four spores). The alga belongs to the genus Scytonema, and is considerably modified in its symbiotic condition. (*Bull. Soc. Myc. France*, vii. 32.)

M. H. Jumelle's researches on the biology of Lichens point to the following conclusions:—(1) The property of reviving after complete and prolonged desiccation, owing to the absence of water of composition, the amount of moisture being dependent on the quantity present in the substratum or body on which the lichen is growing. (2) In all lichens, under favourable conditions of light, temperature, and moisture, the process of assimilation exceeds that of transpiration, owing to the algal element being able to obtain carbon in sufficient quantity from the atmosphere. In the dark, on the other hand, the amount of carbon dioxide exhaled is always less than the amount of oxygen absorbed; the proportions being about the same as those observed in the fungi. (3) As in the higher plants, there is an optimum, or most favourable point for moisture and temperature in connection with the performance of the vital processes. (*Rev. Gén. de Bot.*, iv. 56, and following numbers.)

Schizophyceæ.

Hugo Zukal ("On the Cell-contents of the Schizophytes") points out the difference of opinion of different observers respecting the cell-contents of the Cyanophyceæ, or blue-green algæ. According to some authors, there is present a nucleus, chromotophore, vacuoles, and starch; others assert that all these are absent, and the colouring matter is diffused in the homogeneous or granular protoplasm.

The author has investigated the structure of Tolypothrix lanata Wartm., in the cells of which a nucleus and nucleolus has been described by Wille, Hansgirg, Zacharias, and Scott. In the fresh filaments the cells contain a nucleus containing two or more irregular nucleoli, the latter stain deeper than the former with eosin and haematoxylin, whereas with a watery solution of iodine the opposite effect is produced. The nucleoli of each nucleus fuse into a single, round, brilliant nucleolus, corresponding to the nucleolus of Wille. In the hormogonia of living filaments, each cell, under very high magnification, shows a peripheral coloured layer, and a central, colourless, granular

mass, with no trace of nuclei or nucleoli; thus resembling more an Oscillatoria than the adult state of Tolypothrix; nevertheless, certain of the hormogonia have the cells at the base nucleate, and those towards the apex granular. In cultures of the hormogonia the nucleus was seen to elongate, and along with the nucleolus finally divide into two nuclei; by a repetition of this method four nuclei are formed and ranged in a line, later on eight nuclei are formed by the same process of constriction; these are individually surrounded by a thin layer of protoplasm, and arranged irregularly; finally, when thirty-two nuclei are formed, their special protoplasmic coverings blend with each other, and with the surrounding cytioplasm.

The coloured peripheral layer of the cell is considered as representing a chromatophore. (*Sitzungs. der Kaiserl. Akad. der Wissensch. in Wien.*, ci. 301.)

P. A. Dangeard describes what he considers as an undoubted nucleus in Merismopedia convoluta Bréb., one of the Cyanophyceæ. The nucleus occupies about half the cell, and becomes strongly coloured with hæmatoxylin after fixation in absolute alcohol. Canada balsam was found to be the best mounting medium. (*Le Botaniste*, 1892, p. 28.)

The ginger-beer plant.

H. Marshall Ward has investigated the nature of the compound organism found in home-made ginger-beer fermentations. It is jelly-like, semi-transparent, yellowish-white, and forms brain-like masses or deposits at the bottom of the fermentations, resembling in some respects Caucasian kephir grains, with which, however, it is by no means identical. The jelly-like lumps consist essentially of a symbiotic association of a specific saccharomycete and a schizomycete.

Both these organisms are hitherto undescribed.

Saccharomyces pyriformis (Ward) is an anaerobic bottom-yeast that develops large quantities of carbon dioxide, but forms little alcohol. It has an aerobic form in which the rounded cells grow out into club-shaped or pyriform cells, whence the specific name. It inverts cane-sugar, and ferments the products, but is unable to ferment milk-sugar.

The Schizomycete, Bacterium vermiforme (Ward), has been thoroughly studied. It occurs in the fermentations as curved or straight rodlets or filaments, encased in a very thick, firm, gelatinous sheath, and is so pronouncedly anaerobic that the best results were got by cultivating it in carbon dioxide under pressure.

The jelly-like lumps of the "ginger-beer plant" are essen-

tially composed of the sheathed and coiled bacterium entangling the cells of Saccharomyces pyriformis.

The action on the saccharine solution produced by the bacterium alone is different to that effected by the saccharomyces alone; and both differ from the action of the two organisms, synthesised as a compound organism.

The author succeeded in reconstructing the "ginger-beer plant" by mixing pure cultures of the above two organisms.

In addition to the above, Mycoderma cerevisiæ (Desm.), and Bacterium aceti (Ktzg. and Zopf), were met with in all the specimens which were examined; and as foreign intruders, more or less frequent, various forms of yeast, some of which are probably new, together with various moulds, etc. (*Phil. Trans.*, clxxxiii. 125.)

H. Marshall Ward ("On the Characters, or marks, employed for classifying the Schizomycetes") has contributed some very valuable suggestions bearing on the classification of the schizomycetes. The author considers that the present state of chaos in this relation is due to the unpremeditated absence of touch manifested in the lines of research pursued by two distinct bodies of observers; the botanists, on the one hand, having confined their attention too exclusively to morphological features; while on the other, the bacteriologists have attended too exclusively to the behaviour of their species on certain media.

It is considered as beyond reasonable doubt that the great cause of multiple species has been growth under different conditions. As an illustration, there is evidence to show that a given organism may be anaerobian in saccharine solutions, but aerobian on gelatine; or again, a form which grows like an ordinary bacillus in a saccharine solution may present a very different appearance if cultivated in beef-broth, and so on; hence it is obvious that unless all the conditions are noted under which a form presents a given appearance, or manifests certain characteristics, multiple species must inevitably be the outcome.

The author considers that a congress of bacteriologists might elaborate some international scheme of common agreement for recording the peculiarities of the schizomycetes they meet with, and in the meantime suggests the following questions, all of which, and possibly others, obviously require to be answered before a complete description of a species can be drawn up:—(1) Habitat; (2) nutrient medium; (3) gaseous environment; (4) temperature; (5) morphology and life-history; (6) special behaviour; (7) whether the schizomycete is pathogenic or not, etc., etc.

A history of the different schools of bacteriology, also the most important schemes of classification, are given. (*Ann. Bot.*, vi. 101.)

Myxogastres.

A Monograph of the Myxogastres.—**G. Massee** has given in a book having the above title a systematic revision of all the known organisms included under the names, Myxogastres, Myxomycetes, or Mycetozoa, including 41 genera and 458 species. The primary divisions are founded on the relative development of the capillitium or network mixed with the spores, in its bearing on spore dispersion, and are as follows:—(1) Peritricheæ—wall of the sporangium not incrusted with lime; capillitium absent, or formed from the wall of the sporangium. (2) Columelliferæ—wall of sporangium without lime; capillitium originating from a columella or central axis. (3) Lithodermeæ—wall of sporangium with an external deposit of lime; capillitium present. (4) Calotricheæ—wall of sporangium without an external deposit of lime; capillitium present, not springing from a columella.

The vexed question concerning the vegetable or animal nature is discussed, and after noting that the life-history of these organisms is composed of two abrupt phases—vegetative and reproductive—attention is drawn to the fact that all the arguments formulated by De Bary and others, who consider the Myxogastres as being outside the vegetable kingdom—in other words, as belonging to the animal kingdom—are derived from the vegetative phase, whereas all the points of differentiation that give individuality to the group are entirely confined to the reproductive phase, and probably determined by the change from an aquatic to a terrestrial habitat. The occurrence of hybrids suggests the probability of conjugation between the components of a plasmodium.

Figures of the species and microscopic details are given on twelve chromo plates. (Methuen and Co., London.)

MINUTE ANATOMY OF PLANTS.

BY D. H. SCOTT, M.A., PH.D., F.L.S.

THE year 1892 has not been specially fertile in works of general importance, relating to the internal structure of plants, or in histological discoveries of wide bearing. In both these respects the year contrasts unfavourably with 1891. The actual amount of work produced is, as always, very large, and even the number of papers which appear to require some notice here is considerable.

As a rule, however, their scope is somewhat limited, and their interest rather special than general. Some important papers published at the very close of the year can only be noticed in the next volume of this "Year-Book."

HISTOLOGY.

The most interesting work which has been done in this part of the science is on fertilisation.

Hitherto there have been very few investigations of the details of this process in the lower flowerless plants, especially as regards the behaviour of the nuclei of the sexual cells. A paper by **Klebahn**, "On the fertilisation of a species of Œdogonium," is of much interest from this point of view. Œdogonium, a genus of filamentous fresh-water Algæ, has large nuclei, which have long been known to divide by the same karyokinetic process as those of the higher plants. The author has traced the nucleus of the spermatozoid during its passage through the protoplasm of the ovum, and has seen it fuse with the female nucleus. The group of male chromatic elements can even be distinguished within the nucleus of the ovum after fusion has taken place.

The author thinks that the cells which are cut off immediately below the oogonium may have the physiological significance of polar bodies. (**Klebahn**, "Studien über Zygoten, II." *Pringsheim's Jahrbuch für wissenschaftliche Botanik*, xxiv. 235.)

In the case described there is a striking difference between the male and female nuclei at the time of their union. The male is smaller and relatively richer in chromatine than the female. A certain school of investigators lay great stress on differences of this kind. Others, as for instance Guignard and Strasburger, regard them as non-essential, depending on the stage of development and not on sex. **Zacharias**, who claims to have established a chemical difference between the sexual nuclei, replies to Guignard (*see* "Year-Book," 1891, p. 444). Guignard, working at Phanerogams, had pointed out that when the united nuclei of the fertilised ovum prepare for division, they are for the first time in a strictly comparable condition, and that then there is no difference between the male and female segments. Zacharias answers that by that time the two nuclei may have reacted on each other, and equalised the differences which existed at an earlier stage. He insists that there must of necessity be a difference between the sexual nuclei, otherwise we could not explain the inability of the ovum to develop without fertilisation. On the theories of Weismann, Guignard, and Strasburger, however, the distinction between two sexual

nuclei is on a par with the distinction between two individuals of the same species, and must therefore be quite inaccessible to microchemical tests. (**Zacharias**, *Bot. Zeitung*, l. 246.)

Schottländer and **Rosen**, the former working with Ferns and Liverworts, the latter with Liliaceæ, endeavour to demonstrate a difference in colour reactions between the male and female nuclei. Similar statements had been made in the case of vertebrate animals by Auerbach. The male nucleus is said to have a special affinity for blue stains, the female for red. As these reactions are independent of the chemical composition of the stains employed, the significance of such observations is obscure. (**Schottländer**, *Berichte d. deutschen bot. Gesellschaft*, x. 27; **Rosen**, *Cohn's Beiträge z. Biol. d. Pflanzen*, v. 443; see also **Schottländer**, *Cohn's Beiträge*, vi. 267.)

Chauveaud has investigated fertilisation in certain cases of polyembryony. In Vincetoxicum, for instance (N. O. Asclepiadaceæ), several embryos are normally matured in each seed. He finds that in these cases *all* the cells at the apex of the embryo-sac are functional ova, and may exceed three in number. He appears to regard this as the primitive condition in Angiosperms. He finds only a single pollen-tube present in these cases, and explains the multiple fertilisation by the unusually large number of generative nuclei found in the pollen-tube.

Chauveaud finds that in Vincetoxicum the ovule has no integument, and that the embryo-sac is derived directly from a hypodermal cell without previous divisions—an unusually simple condition in Dicotyledons. (**Chauveaud**, *Comptes Rendus*, cxiv. 313 and 504.)

Mottier records a new case (in Arisæma triphyllum, N.O. Aroideæ) of the longitudinal division of the embryo-sac mother-cell, into three or four embryo-sacs, only one of which, however, develops further. (**Mottier**, *Bot. Gazette*, xvii. 258.)

There is very little to note in general histology. **Crato** claims to have discovered a new organ in the cell. The bodies observed (which he calls physodes) are utricular swellings on the strands of protoplasm crossing the cell-cavity. They have fluid contents, which usually give the reactions of phloroglucin. The physodes show active amœboid movement, and may put out branches. They do not increase by division, but arise *de novo* from the protoplasm. The author regards them as easily transportable reservoirs of plastic substances. They were found in all cells investigated, but the observations were chiefly made on a brown seaweed, Chætopteris plumosa. (**Crato**, *Ber. d. deutsch. bot. Gesellschaft*, x. 295.)

Gerassimoff has investigated the cells without nuclei which are sometimes found in Spirogyra and its allies. In some cases the formation of such cells can be induced by lowering the temperature; the division of the nucleus is thus checked, while the formation of the cell-wall may continue. The cells without nuclei may form starch, and grow for a time, but sooner or later they perish.

An interesting incidental observation is that the lowering of temperature may cause the nucleus to divide directly, instead of by the usual process of karyokinesis. (**Gerassimoff**, "Uber die kernlosen Zellen bei einigen Conjugaten," *Bull. Soc. Imp. des Naturalistes de Moscou*, 1892, 109.)

The question as to the existence of a nucleus in the blue-green Algæ, or Cyanophyceæ, continues to receive attention. Most recent authors have regarded the central fibrillar body as representing the nucleus, if one be present at all. **Zukal**, however, endeavours to show that certain granules in the protoplasm are the nuclei. His views are explained more fully on p. 482. **Hieronymus** returns to the former opinion, and gives a very full account of the supposed nucleus, which he proposes to distinguish as an *open* nucleus from that of higher organisms, a nuclear membrane being absent in the Cyanophyceæ. **Zacharias** criticises both papers, chiefly from a micro-chemical point of view. Until we have some definite evidence as to the behaviour of the supposed nucleus during division, the solution of the problem appears hopeless. (**Zukal**, *Ber. d. deutsch. bot. Gesellschaft*, x. 51; **Hieronymus**, *Cohn's Beitr. z. Biol. d. Pflanzen*, v. 461; **Zacharias**, *Bot. Zeitung*, l. 617.)

Dodel has very fully investigated the development of the starch-grains in Pellionia Daveauana (N. O. Urticaceæ), which appears to be the most favourable object for the purpose yet discovered. He fully confirms Schimper's results as to the formation of starch-grains by protoplasmic plastids. Such valuable evidence, supported by a most complete series of figures, is especially welcome just now, when doubt has been cast on the significance of plastids. (**Dodel**, *Flora*, 1892, 267.)

A paper by **Correns**, on the seeds of Cuphea, describes what may fairly be called a histological curiosity. It is already known that these seeds, and those of some other Lythraceæ, when moistened, develop long hairs, which in twenty-four hours attain a length equal to the breadth of the seed. The author has now cleared up the history of these strange formations. In the epidermal cells of the seed-coat a singular ingrowth of the cell-wall is present, forming a hollow thread,

coiled up in the cavity of the cell, and attached by one end to the outer wall. When the seed is wetted the portion of cuticle lying above the attachment of the thread opens as a lid, and then the thread turns itself inside out, like the finger of a glove, at the same time straightening itself to form the hair which now projects freely from the surface of the cell. The thread contains a mucilage, which is expelled by the process of eversion, and causes the hairs to adhere firmly to the soil in which the seed may be lying. This curious phenomenon is quite independent of the life of the cell, going on as usual in seeds which have been killed in alcohol. (**Correns**, *Ber. d. deutsch. bot. Gesellschaft*, x. 143.)

ANATOMY.

General.

The question of the limit between stem and root is discussed by **Van Tieghem**. This limit may be defined either by external or by internal characters: by the epidermis or by the vascular cylinder. In the Monocotyledons, where the whole of the epidermis of the root (according to the terminology of the French anatomist) is exfoliated, the line of detachment affords a satisfactory demarcation, which agrees sufficiently well with the transition in the vascular region. In Dicotyledons the inmost layer of epidermis remains adherent to the root. Here we can only arrive at a definite external limit between the two organs by taking the first tangential wall in the epidermis as the borderline. This, however, by no means always corresponds to the change in internal structure. The author thinks that it is on the latter alone that the demarcation can safely be based, as this always affords a definite criterion, while the epidermal limit is variable and often doubtful. (**Van Tieghem**, *Jour. de Bot.*, v. 425.)

Lopriore has investigated the regeneration of roots which have been split down the middle. The normal structure is almost always completely restored, all the tissues taking part in the new development. A wound-tissue or callus is first formed, in which a meristem appears by the activity of which the missing tissues are regenerated. The process is often accompanied by an abnormal development of branch-roots, which are frequently "congenitally coherent," *i.e.*, several of their vascular cylinders are more or less united from the first, and are enclosed within a common cortex. (**Lopriore**, *Ber. d. deutsch. bot. Gesellschaft*, x. 76.)

Siedler writes on the radial current of sap in roots. The paper is mainly anatomical, and chiefly concerns the outer or hypodermal

layers of the cortex in roots (including the exodermis). The author finds reason to believe that these layers act as a water-reservoir, on which the root can draw in time of need. (**Siedler**, *Cohn's Beitr. z. Biol. d. Pflangen*, v., *Heft* 3.)

Another paper may be mentioned here as having some bearing on the water current in plants. **Benecke** has examined the subsidiary cells, *i.e.*, the modified epidermal cells, which often accompany the stomata. He gives a classification of stomata, based on the presence or absence, and on the arrangement of these cells. He is unable to determine their exact function, but points out that they are so placed as to protect the stomata against the effects of drought. (**Benecke**, *Bot. Zeit.*, l. 521.)

Passing on to the cambium and its products, a paper by **Krüger** on the thickenings on the walls of cambial cells must be noticed. These thickened ridges are always present in the radial walls of the cambium, in Dicotyledons, Monocotyledons, and Gymnosperms. They can he traced even in the procambial tissue from which the primary vascular bundles are developed. The thickenings represent the first indications of the ultimate sculpturing of the cell-walls; the thin parts between the ridges become pits or sieve-plates. In the cambium they are less conspicuous in summer than in winter, simply because during active growth all the cell-walls become radially stretched, and are thus made thinner in all their parts. There is no evidence that the thickening masses are ever reabsorbed. (**Krüger**, *Bot. Zeit.*, l. 633.)

Raatz has investigated the rod-like processes of the cell-wall which occur in the cambial cells and their derivatives, not only in Conifers, but in Casuarina and some Dicotyledons. As these structures are handed on to all the descendants of the cambial cell which originally possessed them, they afford a convenient means of tracing the participation of individual cells of the cambium in the formation of the secondary tissues. As the result of his investigation, the author finds that there are no definite initial cells as Sanio supposed, but that any cell of the cambial region may go on dividing indefinitely, if its position be favourable. (**Raatz**, *Pringsheim's Jahrbuch f. wiss. Bot.*, xxiii. 567.)

The controversy on the causes of the formation of annual rings in trees is still active. **Hartig** publishes a reply to **Jost's** paper, noticed in the "Year-Book" for 1891, p. 451, and Jost again replies to Hartig. The latter insists on the importance of increased nutrition as a cause of the formation of the thick-walled autumn wood. He shows that, as the reserves of food are but

little utilised for the purpose of forming wood, the development of dense wood must depend on assimilation by the leaves, which goes on most energetically in the height of summer, when the so-called autumn wood is being formed. Hartig, however, now only offers this explanation to account for the thickness of the cell-walls; the nature of the elements formed he regards as a specific character of the tree in question, while the size of the cavities of the vessels is dependent on transpiration, and the consequent intensity of the water current. Jost, on the other hand, is inclined to refer the phenomenon of annual rings to internal causes, and to regard it as directly dependent on the development of the annual shoots. He admits, however, that abundant nutrition is a necessary condition for the formation of dense wood, but points out that we at present possess no evidence as to the nutrition of the cambium at different seasons. On the whole Hartig tends to a purely physiological explanation by means of assimilation and transpiration, while Jost relies rather on correlation of growth.

Wieler, like Hartig, attributes much importance to the effect of nutrition, but he places its maximum in spring, and regards the large-celled spring wood as the best fed. While Hartig chiefly aims at explaining the relative thickness of the walls, Wieler's theory is only intended to account for the radial diameter of the elements. He endeavours to support his opinion by showing that under favourable conditions not only does the breadth of the whole annual ring increase, but also the radial diameter of the individual elements. He shows that the more abundant is the water-supply of the cells, the more do they grow in the radial direction.

It is satisfactory to find that all authors now agree that only the *dimensions* of the elements are directly dependent on external conditions. The histological character of the tissues, whether formed from the cambium or otherwise, will certainly require some more profound explanation, which is probably reserved for the distant future. (**Hartig**, *Bot. Zeit.*, l. 193; **Jost**, ditto, 489; **Wieler**, *Tharander Forstliches Jahrbuch*, xlii. 72, *Abstract*, *Bot. Centralblatt*, lii. 62.)

Dahmen publishes an elaborate paper on the anatomy and physiology of the funiculus of seeds. (*Pringsheim's Jahrbuch f wiss. Bot.*, xxiii. 441.)

An interesting paper on the structure of the leaf in Alpine plants has been written by **Wagner**. He finds, in agreement with the conclusions of Gaston Bonnier, that the leaves of the great majority of Alpine plants are adapted to intense assimilation.

These leaves show an exceptional development of the palisade parenchyma, which is the assimilating tissue *par excellence.* In many cases the adaptability of the same species is remarkable, Alpine individuals having much more abundant and characteristic palisade tissue than those grown in the plain. A large proportion (39 per cent.) of the Alpine plants investigated had more stomata on the upper than on the under surface of the leaf. The stomata are freely exposed on the surface of the epidermis, and the inner tissues of the leaf have abundant intercellular spaces. All these characters are regarded by the author as being primarily adaptations to increased assimilative activity. This he explains (1) by the much greater intensity of sunlight at high levels; (2) by the diminished amount of CO_2 available; and (3) by the shortness of the period of active vegetation. Many other points of interest will be found in the paper. (**A. Wagner,** *Zur Kenntniss des Blattbaues der Alpenpflanzen Sitzungsber d. k. Akad. d. Wiss. nat. math. Classe. Wien.*, ci. 1, 487.)

Special.

Among papers on systematic anatomy **Van Tieghem's** completion of his work in the Melastomaceæ is important. The author has now examined sixteen additional genera, and is thus enabled to complete his classification of the whole of this great order in accordance with the anatomical characters. As an example of the skilful employment of anatomy in classification, the work is of special value. The author points out the general agreement between the results of anatomical and of morphological investigation. He insists that there can never be any real contradiction between well-established external characters and internal characters properly appreciated, *if differences due to adaptations be left out of account.* The reservation, it will be seen, is an important one. In a footnote the author mentions a point of general anatomical interest: the cortical bundles present in so many Melastomaceæ have a peridesm (*see* "Year-Book" for 1891, p. 450) and endodermis of their own, while the bundles in the pith possess no other elements than those of the bast and wood. (**Van Tieghem,** *Ann. des Sci. Nat. Bot.* [vii.], xv. 369.)

Von Schlepegrell has given a full account of the anatomical characters of the Tubifloræ, embracing the natural orders, Hydrophyllaceæ, Boraginaceæ, Polemoniaceæ, Convolvulaceæ, Nolanaceæ, and Solanaceæ. Such summaries are very necessary from a systematic point of view, even though they may contain few

additions to anatomical knowledge. (**V. Schlepegrell**, *Bot. Centralblatt*, xlix. 194.)

Vesque, in a paper on the anatomy of the tribe Clusieæ, discusses the general question of the value of anatomical characters. Otherwise the paper is of purely systematic interest. (**Vesque**, *Jour. de Bot.*, vi. 81.) The same may be said of papers by **Chodat** and by **Ross** on the anatomy of the leaves of Iridaceæ. (**Chodat** et **Balicka-Iwanowska**, *Jour. de Bot.*, vi. 220; also in *Laboratoire de Botanique de Genève*, I.; **Ross**, *Malpighia*, v.)

It is well known that in several genera of Dicotyledons strands of phloëm are present, embedded in the wood. In some cases they are formed on the inner side of the cambium, and thus belong by development as well as by position to the wood; in others they are formed, like normal phloëm, on the outer side of the cambium, and only become enclosed in the wood at a later stage. **Chodat** has fully investigated this question in the case of the Malpighiaceous genus, Dicella, and finds that its "phloëm-islands" belong to the former category, while in Strychnos, as has been known for some time, the reverse is the case. Investigations by Chodat and **Roulet** appear to show that Thunbergia (N. O. Acanthaceae) agrees with Dicella, while the similar anomaly in the Aquilarieæ, a tribe of Thymelæaceæ, has, according to Van Tieghem, the same origin as in Strychnos. (**Chodat**, *Laboratoire de Botanique de Genève*, i.; *Extrait des Archives des Sciences Phys. et Nat.*, xxvii. 229 *dit.*; **Van Tieghem**, *Jour. de Bot.*, vi. 217.)

Borzi has investigated some curious anomalies in certain Cruciferæ. In *Brassica fruticulosa* and in *Erucastrum virgatum* he finds that the vascular bundles of the stem have phloëm on their inner as well as on their outer side. He also finds phloëm embedded in the wood of both root and stem. It is formed on the inner side of the cambium. These peculiarities are exceptional in the order Cruciferæ. The same author shows that among the Leguminosæ, Phaseolus Caracalla develops groups of phloëm in the parenchymatous part of its wood. (**Borzi**, *Malpighia*, v. 316 and 372.)

As regards secretory tissues, there is a paper by **F. E. Weiss**, on the curious caoutchouc-containing cells of Eucommia ulmoides, a Chinese plant of doubtful affinities. These cells form a connecting link between ordinary secretory sacs and the enormous branched laticiferous cells of certain Euphorbiaceæ and other Dicotyledons (*see* "Year-Book" for 1891, 447). The caoutchouc-cells of Eucommia arise in pairs, by the division of a cortical cell. They grow to a great length, but do not branch. The author

correlates the absence of branches with the fact that the nucleus remains undivided. These cells are formed not only in the young organs of the growing points, but also in the secondary phloëm, thus differing from the true laticiferous cells, which never arise *de novo* anywhere except in the embryo. These results, interesting in any case, will prove doubly so if the supposed Euphorbiaceous affinities of the genus should be confirmed. In that case we might regard the secretory cells of Eucommia as representing a stage in the evolution of the laticiferous cells proper, which form so striking an anatomical feature in other members of the order. (**F. E. Weiss**, *Linn. Soc. Trans. Bot.* [2], iii. 243.)

Barber has investigated the development of the remarkable corky excrescences on the stem of Zanthoxylum. He finds that these conical outgrowths always arise beneath a thorn, and just outside an internal gland. A meristem appears in this position, which produces towards the outside very abundant layers of cork, by which the thorn is gradually raised up. At a later stage the thorn becomes detached and the prominent corky growth alone remains. The author enumerates many other plants in which basal formation of cork below thorns takes place. (**Barber**, *Ann. Bot.*, vi. 155. *See* also p. 469.)

Raatz has made an interesting contribution to our knowledge of thyloses, having for the first time discovered these structures in the wood of Coniferæ. These hernia-like growths arise in this case from cells of the medullary rays. They not only penetrate into the tracheides, but also into empty cells of the rays themselves, completely filling up the cavities which they invade, and giving rise to most complicated structures. The author finds that they almost always arise in connection with wounds. The same stimulus which starts the formation of wound-callus, also calls forth the luxuriant internal growth to which thyloses are due. The phenomenon is most common in the root. (**Raatz**, *Ber. d. deutsch. bot. Gesellschaft*, x. 183.)

Poirault has continued his investigations on the anatomy and development of Ophioglossum. In some species the roots have a normal structure; in others, as the British adders-tongue (*O. vulgatum*), the root-cylinder is anomalous, including only one bundle of xylem and one of phloëm. The author shows that this distinction is not constant, the normal species occasionally forming anomalous roots, and *vice versa*. In all roots of the genus, however, the pericycle is absent opposite the phloëm.

The author confirms Van Tieghem's opinion that the stem of Ophioglossum is astelic (*see* "Year-Book," 1891, 454). In *O.*

capense, near the base of the stem, each bundle has a clear endodermis of its own; higher up the stem only a few cells show the characteristic endodermal structure. The true endodermis turns out to be the layer next the bundle, which Van Tieghem regarded as peridesm.

Besides the buds nominally formed on the root ("Year-Book" for 1891, 454), endogenous buds may arise on fragments of the root. They are not connected with the vascular cylinder of the parent organ. Similar buds may be formed on fragments of the stem, so that the genus possesses abundant means of vegetative propagation. (**Poirault**, *Jour. de Bot.*, vi. 69.)

Rostowzew has published a valuable preliminary communication (of considerable extent) on Ophioglossum. He has investigated the details of the growth of stem and root, which takes place by means of a single apical cell in each case. He mentions that the stem has a slight secondary growth in thickness, but reserves anatomical particulars for his full paper. (**Rostowzew**, *Oversigt over. d. K. Danske Videnskab Selskabs Forhandlingar*, 1891, 54.)

Botrychium virginianum has been investigated by **Holtzman**, who finds that there is a single apical cell at the growing point of the stem, thus confirming current views. (*Bot. Gazette*, xvii. 214.)

It is well known that some species of Equisetum produce subterranean tubercles, which serve for vegetative propagation. These organs have been examined by **Leclerc du Sablon**. Each tubercle consists of a single internode. In E. Telmateia they occur singly, as branches on the rhizome; in E. sylvaticum they form chaplet-like series. The vascular bundles of the tubercle form an irregular network, and differ considerably from those of the rhizome itself. Each bundle has its own endodermis (even when the rhizome is apparently monostelic); it has no intercellular space, and does not show the characteristic v-shape, the protoxylem elements being irregularly scattered. (*cf.* "Year-Book," 1891, 454; **Leclerc du Sablon**, *Revue générale de Bot.*, iv. 97.)

The anatomy and physiology of mosses are considered in a paper by **Coesfeld**. This author differs from previous investigators in regarding the central cylinder, even of the highest mosses, such as Polytrichum, as of uniform structure throughout, and presenting no trace of differentiation between xylem and phloëm. All the cells of the cylinder are said to retain their living contents. The function of the cylinder is regarded as consisting chiefly in the storage of water on the one hand, and in the conduction of carbohydrates and proteids on the other. (**Coesfeld**, *Bot. Zeitung*, l. 153.)

The subject of the anatomy of the higher Algæ has received an important contribution from **Guignard**. Many of the Laminariaceæ,

the most complex family of seaweeds from an anatomical point of view, are known to possess a special apparatus for the secretion of mucilage. Guignard has thoroughly investigated the structure and development of the secretory organs in various species of Laminaria, and has summed up our knowledge of the distribution of such organs throughout the family.

The canals in which the mucilage is to be contained first arise as little spaces, formed by the splitting apart of some of the youngest cortical cells, quite near the giving point. At first the cells bordering on the space do not differ from their neighbours. Soon, however, one or more small cells are cut off on the inner side of each space. These small cells are the actual secretory organs by which the mucilage is formed.

In the meantime the intercellular spaces spread, by the further separation of cortical cells, so as eventually to form a complex network of canals, parallel to the surface of the stem or lamina. The secretory cells form isolated groups or masses, projecting at irregular intervals into the cavity of the canals, from their inner side. Branch canals lead outwards from the cortical network as far as the epidermis, but do not penetrate to the surface. This form of secretory apparatus is at present quite unique among plants.

It occurs very irregularly in the order Laminariaceæ. Thus among our native oarweeds *L. Cloustoni* possesses the secretory organs both in leaf and stem, *L. flexicaulis* and *L. saccharina* in the leaf only, while *Saccorhiza bulbosa* and *Alaria esculenta* appear to be quite destitute of them. (**Guignard**, *Ann. des Sci. Nat. Bot.* [7], xv. 1.)

PHYSIOLOGY OF PLANTS.

By Prof. F. E. Weiss, B.Sc., F.L.S.

General.

J. Wiesner concludes that there must be some limit to the divisibility of the living organised substance, and by analogy to the ultimate particles of the cell wall he terms the corresponding particles of the protoplasm "plasomes." These plasomes are able to assimilate, to grow and divide, and the growth and division of such bodies as the nuclei and chloroplasts represent the sum of the changes of their constituent plasomes. These must not be confounded with molecules of organic matter, which make up the plasome and which are themselves devoid of independent life. The entire cell is built up of plasomes, and even the cell

wall consists of such particles, which have, however, undergone a change, and have become transformed into "dermatosomes."

The question whether these plasomes besides their other properties are the ultimate particles to which stimuli can be transmitted, Wiesner does not wish to answer; but, on the other hand, he is convinced that all plasomes are the carriers of hereditary characters. In the development of the plant some plasomes become permanently altered, to form dermatosomes, etc., but others remain in what may be called a meristematic condition, and these constitute the germ plasm, which exists in all the cells of the plant. (*Die Elementarstructur und das Wachsthum der lebenden Substanz*, Vienna, 1892.)

O. Bütschli works out still further the analogies between his artificial protoplasma-like emulsions and living protoplasm, and insists on his former conclusion that protoplasm is built up of a number of microscopic vesicles which by pressure give to it a structure resembling that of a honeycomb. Small particles are always found at the angles and certain stains are taken up by this artificial protoplasma. The fibrillated appearance of real protoplasm is due to methods of preservation, as living protoplasm shows a vesicular structure. Protoplasmic movement is due to diffusion of substances into the vesicles and consequent rupture of the same, which disturbs the equilibrium of the mass, and entails certain mechanical displacement of the remaining vesicles. (*Untersuchungen über Mikroscopische Schäume und das Protoplasma*, Leipzig, 1892.)

P. Klemm discusses the state of aggregation of protoplasm, and concludes that by this term various apparently identical but in reality very different phenomena have been described.

Aggregation in the cells of insectivorous plants may be brought about by contact stimuli, and is therefore a special phenomenon. Aggregation in the cells of Spirogyra, however, can only be brought about by chemical means, and is an act by which some substance is excreted. (*Flora*, l. 395.)

P. Hauptfleisch states that in cells surrounded by a cell wall the streaming movement of protoplasm does not take place until the vacuole has increased to a certain size. The presence of oxygen he finds is essential for protoplasmic movement. If the latter has ceased it will only recommence in the presence of oxygen under pressures of 1·2 to 2·8 mm. of mercury. Still the author does not consider the movement to be caused by the presence of oxygen, but to be due to some internal force which cannot, however, manifest itself in the absence of oxygen. (*Jahrb. f. wis. B.*, xxiv. 173.)

W. Pfeffer appears as a pioneer in that branch of vegetable physiology which deals with the study of energy in plants. He regrets the tendency to look upon the energy which is gained by respiration as the sole source of the working forces of plants, while, as a matter of fact, potential energy is gained more largely from other sources. In connection with respiration, he dwells upon the fact that where it is unaccompanied by a rise of temperature—in plants, for instance—the energy gained is greater than in warm-blooded animals, where a large amount of heat is lost by radiation. This applies also to the energy derived from metabolic processes in the plant, in which almost all the units of heat evolved by chemical changes are transformed into potential or kinetic energy. Absorption of energy from without takes place by absorption of food, light, and, as plants are isothermal, also of heat. With regard to the absorption of light, most is known about the ultimate fate of the red and yellow rays absorbed by the chlorophyll, but, as Engelmann has shown, in plants devoid of chlorophyll, organic substance can result from the absorption of rays from the blue end of the spectrum. Pfeffer, however, concludes that the energy due to absorption of light is not nearly as great as that due to the absorption of food, and that even in the case of assimilation the energy obtained by the plant is due more to the absorption of the carbon of the carbonic acid than to the rays of light. (*Abh. d. K. Sächs. Ges. d. Wiss.*, xxxi. 151.)

H. Voechting has made experiments on the transplantation—from one part of a plant to another—of tissues and organs, both in herbaceous and in woody plants. In the case of the former, he cut blocks of tissue out of the succulent root of the beet, and found that such pieces may be transferred and readily reunite with the root into which they are placed, forming a new cambium layer and increasing in thickness. If the blocks are turned upside down, disturbing influences are set up which show themselves in abnormal growths such as swellings, etc., whence Voechting concludes that the polarity which he had found to exist in organs is also characteristic of the individual cells making up any organ.

Entire organs may be grafted on the various parts of a plant. Roots may be planted on stems and even on leaves, and the latter, though they have a limited growth, will form connection when grafted on stems or roots. Some of the most interesting experiments made were the grafting of a branch of the inflorescence, *i.e.*, of the second year's growth, of the beet on the root of the first year. In this case no flowers were produced, as should have been the case in biennials, but the buds developed

into flattened leafy rosettes resembling the tops of the first year, and behaving as such. When young stems of the first year, on the other hand, were grafted on old second year's roots, they elongated and behaved like second year's shoots. Hence he concludes that in biennials the root draws upon the assimilating organs during the first year, but that in the second year the inverse current is set up, and the food substances are passed upwards. (*Transplantation am Pflanzenkoerper*, Tübingen, 1892.)

Fr. Hildebrand finds that in cuttings, as well as in seedlings, a more primitive form of the leaf will be formed than in the adult plant. Also, when cut back very vigorously, Acacia cornigera and A. melanoxylon form a profusion of new shoots exhibiting a more primitive type of leaf, characteristic of the seedling and cutting. (*Bot. Zeit.*, l. 1.)

E. Heinricher discusses some cultivation experiments made with specimens of Iris pallida in which two whorls of stamens were developed, a condition which has been acknowledged to be a case of reversion. He finds that the percentage of such flowers on one plant varies considerably from year to year, but does not vary in accordance with any ascertained external condition, as different plants vary considerably when grown under the same conditions. In the offspring this tendency has been handed down to a third generation, and then reversions occur with increasing frequency. (*Jahrg. f. wiss. Bot.*, xxiv. 52.)

Nutrition.

T. Sachs gives an account of the felted mass of root hairs formed in plants cultivated in pots, a phenomenon he ascribes to the cramping to which the root system is subjected. The root hairs are thus produced in those parts of the soil in which least food material is found, while the centre of the pot is almost untouched by them. The only remedy for this unprofitable state of growth has been the temporary expedient of repotting into larger pots. The growth of seedlings in large pots, however, is neither economical nor advantageous, and the author gives an account of a very simple method employed by himself with signal success. The inner wall of the pot he coats with food-substances, which are gradually absorbed by the plant. He finds gypsum is a convenient substratum for soaking with a nutritve solution, as it becomes slowly disintegrated and broken up by the rootlets. (*Flora*, l. 171.)

Th. Bokorny shows how the character of a cell of Spirogyra is changed by differences of nutrition. Cells grown in solutions containing potassium phosphate grow twice as long as those which are devoid of phosphate, while the absence of potassium

prevents assimilation and causes the chromatophore to form a loose spiral. (*Biol. Centralbl.*, xii. 321.)

Stange.—The author's observations prove that within certain limits the osmotic activity of the cells increases with the concentration of the substratum. As long as the cells still live the pressure within the cell will exceed the pressure of the surrounding fluid, and the balance of pressure in favour of the cell may amount to 13·6 atmospheres, even to 20 atmospheres in the roots of the bean, while the normal pressure is 5. But in young growing cells the delicate cell walls are not so resistant, and will often be ruptured. With increasing concentration a diminution both of the rate of growth and of the actual increment of growth takes place, a diminution which is more pronounced in the root than in the stem. Hence De Vries' statement that increase of turgidity and increase in length go hand in hand is not of universal application. But increase in thickness is not governed by the same laws. Two to four per cent. solutions of glycerine cause a diminution in length but a considerable growth in thickness. Hence the protoplasm of the primary meristem would seem to behave differently from that of the cambial cells under apparently the same conditions of pressure. The chemical stimulus on the protoplasm, however, may be different owing to the absence of starch and glycose, which are usually not formed when plants are growing in strong saline solutions. This absence may be due to the formation of other organic substances, such as organic acids, which would greatly increase the turgidity of the cells. Consequently not only the taking up of salts, but the change in the assimilation, may increase the turgidity of the cells.

From these experiments we may conclude that Phanerogams can adapt themselves to considerable concentrations of the substratum. In the absence of light, or when assimilation is stopped by other means, no increase in turgidity takes place in the cells. This may be due either to the great increase of length in darkness, or to the fact that no osmotically attractive substances are formed, or, lastly, to the lessened absorption of salts by the roots. (*Bot. Zeit. Jahrg.*, l. 253.)

A. Richter made somewhat similar experiments with freshwater Algæ, and found that by gradual concentrations many could be accustomed to solutions of common salt. The lower forms lent themselves most readily to these experiments, but even with **Spirogyra**, **Vaucheria**, and **Chara** he was successful. In **Rhapsidium** and **Anabaina** an alteration in the shape of the Algæ was noticed, while **Tetraspora** changed its mode of division. (*Flora*, l. 4.)

O. Loew shows that neutral oxalates and oxalic acid are not

only poisonous to Phanerogams, but also to Algæ. This effect is probably produced by the oxalates abstracting calcium from the cells to form calcium oxalate, and thus removing a substance which, according to Loew, enters largely into the constitution of the chlorophyll bodies and the nucleus. This he concludes must be the mode of action, as magnesium salts also act poisonously in vegetative cells in the absence of calcium salts. In that case magnesium is probably replaced by calcium drawn from chemical combinations in the nucleus and in the chlorophyll bodies. If, however, calcium salts are present, they supply the calcium, and the nucleus and plastids remain unaltered. (*Flora*, l. 368.)

C. Wehmer.—From the analysis of the ashes, the author proves that there is no decrease of potassium nor of phosphates in the leaf during the summer, and very little during the autumn; and he comes to the conclusion that there is no evidence of a backward flow of these substances into the stem previous to the fall of leaves. (*Ber. d. deutsch. bot. Ges.*, x. 153.)

W. Palladin.—The author finds that etiolated leaves contain less mineral salts than green leaves, and concludes that growth in darkness causes a diminished absorption of mineral salts, especially calcium carbonate. This is due to a lack of transpiration, for a similar state of things occurs in plants grown in an atmosphere saturated with water-vapour. (*Ber. d. deutsch. bot. Ges.*, x. 179.)

Respiration and assimilation.

H. Jumelle states that both respiration and assimilation increase with the increase of water in a previously dry specimen, up to a certain point, when these processes stop altogether. Lichens can resist very high temperatures. Respiration remains normal after three days at 45° C., fifteen hours at 50°, five hours at 60°. Assimilation, however, is stopped, owing to the death of the algal constituent of the lichen. Respiration will continue at as low a temperature as − 10°, while assimilation goes on at − 40°. This is also the limit for assimilation in some conifers. (*Rev. gén. de bot.*, iv. 49.)

W. Detmer.—According to Clausen, the optimum temperature for normal respiration is 40° C., while the optimum temperature for fermentation lies between 25° and 30°. Hence Detmer concluded that in higher plants the optimum for intramolecular respiration might be lower than 40°. This, however, is not the case. The optimum temperature for normal respiration coincides with that for intramolecular respiration. (*Ber. d. deutsch. bot. Ges.*, x. 201.)

E. Schunk and **G. Brebner**, from experiments on the action of aniline on green leaves and other parts of plants, come to the

conclusion that the cells of many plants, especially of the leaves, contain some form of active oxygen associated with the protoplasm during the living state of the cell. This oxygen is a more active form than that in ordinary air, or else there is present some oxygen-carrier which is at the same time an oxygen-intensifier, thus bringing about the necessary physiological respiration. (*Ann. Bot.*, vi. 167.)

Irritability.

C. Correns finds that plants differ very much with regard to the amount of oxygen which is necessary to keep up the irritability of their cells. Drosera will respond to stimuli in the presence of the smallest possible trace of oxygen. He discusses the question whether the non-performance of movements is due to loss of perception or the inability to respond. Generally speaking, the perceptive faculty is, he finds, more quickly affected by the absence of oxygen than the responsive power. (*Flora*, l. 87.)

Symbiosis.

B. Frank points out that the cortical layers of root-tubercles of the leguminosæ, though surrounded by cork layers, resemble the lenticel tissue, the cork cells being split apart and allowing free access to the air. (*Ber. d. deutsch. bot. Ges.*, x. 5.)

In a further paper on the roots of the bean, the author distinguishes two different types of root tubercles. The first to make their appearance are small round tubercles, the later ones are larger digitate or coral-like structures. The former contain bacteroids and stored-up albuminous substances, the latter contain, with the bacteroids, refringent granules of that variety of starch which stains red with iodine (amylo-dextrin). This starch, contained within a fungal cell, Frank looks upon, not as a constructive product of the fungus, but as a destructive product, due to the action of the host plant on the symbiotic fungus. (*Ber. d. deutsch. bot. Ges.*, x. 170.)

H. Mœller contradicts Frank's statements, and states that no real dimorphism of tubercles exists. The older tubercles become curiously enlarged and distorted, showing a fatty degeneration, and do not contain starch, but a substance staining brown with iodine, and probably of the nature of cholestrin. (*Ber. d. deutsch. bot. Ges.*, x. 543).

G. Kossowitsch, after careful experimental cultures, comes to the conclusion that leguminous plants do not take up the nitrogen of the atmosphere through the leaves, but solely through their roots. (*Bot. Zeit.*, l. 697.)

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